THE YOUNGSTOWN SHEET
AND TUBE COMPANY
YOUNGSTOWN OHIO

INTERNATIONAL

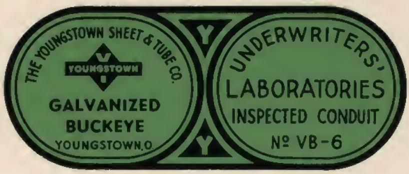
Digitized by

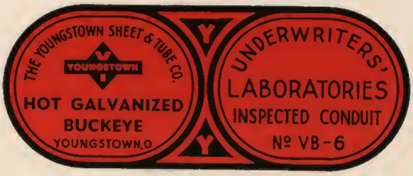
The Association for Preservation Technology International

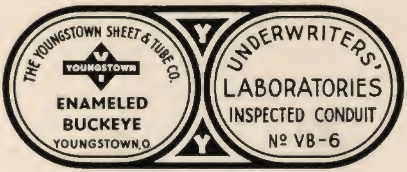
For the

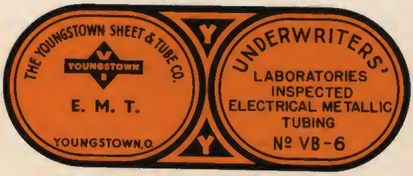
Building Technology Heritage Library

http://archive.org/details/buildingtechnologyheritagelibrary


THE YOUNGSTOWN SHEET & TUBE CO.
YOUNGSTOWN
GALVANIZED
BUCKEYE
YOUNGSTOWN, O.
Y
Y
UNDERWRITERS'
LABORATORIES
INSPECTED CONDUIT
Nº VB-6


THE YOUNGSTOWN SHEET & TUBE CO.
YOUNGSTOWN
HOT GALVANIZED
BUCKEYE
YOUNGSTOWN, O.
Y
Y
UNDERWRITERS'
LABORATORIES
INSPECTED CONDUIT
Nº VB-6


THE YOUNGSTOWN SHEET & TUBE CO.
YOUNGSTOWN
ENAMELED
BUCKEYE
YOUNGSTOWN, O.
Y
Y
UNDERWRITERS'
LABORATORIES
INSPECTED CONDUIT
Nº VB-6


THE YOUNGSTOWN SHEET & TUBE CO.
YOUNGSTOWN
E. M. T.
YOUNGSTOWN, O.
Y
Y
UNDERWRITERS'
LABORATORIES
INSPECTED
ELECTRICAL METALLIC
TUBING
Nº VB-6

Copyrighted 1930 By

THE YOUNGSTOWN SHEET AND TUBE COMPANY
YOUNGSTOWN, OHIO
U. S. A.
Fifth Edition
1936

CONDUIT REFERENCE BOOK No. 5

THE YOUNGSTOWN SHEET AND TUBE COMPANY

YOUNGSTOWN
BUCKEYE
CONDUIT

CONDUIT PLANTS AT
EVANSTON, ILLINOIS
YOUNGSTOWN, OHIO

General Offices:
YOUNGSTOWN, OHIO

DISTRICT SALES OFFICES

ALBANY, NEW YORK	75 State Street
ATLANTA, GEORGIA	Healey Building
BALTIMORE, MARYLAND	3704 Dorchester Road
BOSTON, MASSACHUSETTS	Consolidated Building
BUFFALO, NEW YORK	Liberty Bank Building
CHARLOTTE, NORTH CAROLINA	1621 E. Boulevard
CHICAGO, ILLINOIS	Conway Building
CINCINNATI, OHIO	Carew Tower
CLEVELAND, OHIO	Terminal Tower
COLUMBUS, OHIO	1820 Guilford Road
DALLAS, TEXAS	Continental Building
DENVER, COLORADO	Continental Oil Building
DETROIT, MICHIGAN	Fisher Building
DETROIT, MICH.—Alloy Steel Division	General Motors Building
GRAND RAPIDS, MICHIGAN	1101 San Lucia Drive, S. E.
HOUSTON, TEXAS	Second National Bank Building
INDIANAPOLIS, INDIANA	520 Circle Tower
KANSAS CITY, MISSOURI	Commerce Building
LOS ANGELES, CALIFORNIA	3000 Santa Fe Avenue
MANCHESTER, CONNECTICUT	32 Wellington Road
MEMPHIS, TENNESSEE	P. O. Box 442
MILWAUKEE, WISCONSIN	Mariner Tower
MINNEAPOLIS, MINNESOTA	Andrus Building
NEW ORLEANS, LOUISIANA	Whitney Bank Building
NEW YORK, N. Y.	500 Fifth Avenue
PHILADELPHIA, PENNSYLVANIA	1400 South Penn Square
PITTSBURGH, PENNSYLVANIA	Gulf Building
SAN FRANCISCO, CALIFORNIA	Sharon Building
SEATTLE, WASHINGTON	Central Building
ST. LOUIS, MISSOURI	Shell Building
TOLEDO, OHIO	4402 Berwick Avenue
TULSA, OKLAHOMA	Continental Building
WASHINGTON, D. C.	Shoreham Building
YOUNGSTOWN, OHIO	Stambaugh Building

FOREIGN OFFICE

LONDON, ENGLAND	Dashwood House

PRODUCTS
OF
THE YOUNGSTOWN SHEET AND TUBE COMPANY

MANUFACTURERS OF CARBON AND ALLOY STEELS

RAW AND SEMI-FINISHED MATERIAL

IRON ORE, ZINC ORE, COAL, COKE AND BY-PRODUCTS, PIG IRON, BESSEMER STEEL, OPEN-HEARTH STEEL, INGOTS, BLOOMS, BILLETS, SLABS, SHEET BARS AND SKELP

"YOUNGSTOWN" TUBULAR PRODUCTS

LAP-WELD, BUTT-WELD, ELECTRIC WELD AND SEAMLESS PIPE, CASING, TUBING, DRILL PIPE, DRIVE PIPE, LINE PIPE AND STANDARD PIPE FOR ALL PURPOSES, FROM ONE-EIGHTH TO TWENTY-SIX INCHES IN DIAMETER. SQUARE AND RECTANGULAR TUBING

WE SPECIALIZE IN ALL CLASSES OF OIL COUNTRY TUBULAR GOODS AND LINE PIPE.

MECHANICAL TUBING

HOT AND COLD ROLLED STRIP

IN EITHER COILS OR CUT LENGTHS.

"YOUNGSTOWN" SHEETS

HOT ROLLED SHEETS, HOT ROLLED PICKLED SHEETS, HOT ROLLED ANNEALED SHEETS, HOT ROLLED ANNEALED PICKLED SHEETS, COLD ROLLED SHEETS, FURNITURE SHEETS, AUTO BODY SHEETS, VITREOUS ENAMELING SHEETS, ELECTRICAL SHEETS, "GALVANNEALED" SHEETS, OVEN LINING SHEETS (dull and polished), GALVANIZED SHEETS, "COPPEROID" SHEETS, SPECIAL FINISHED SHEETS FOR ALL PURPOSES, AND IN ALL STANDARD SIZES AND GAUGES, ROOFING AND SIDING, PLAIN CORRUGATED, V-CRIMP, ROLL AND PRESSED STANDING SEAM

TIN PLATE AND TIN MILL BLACK PLATE

PLATES

SHEARED AND UNIVERSAL, PICKLED, OILED OR LIMED

RAILROAD TIE PLATES AND TRACK SPIKES

MERCHANT BARS AND STRUCTURALS

ROUNDS, SQUARES, FLATS, HEXAGONS, OVALS, HALF ROUNDS, FORGING BARS, RODS, ANGLES, BEAMS, CHANNELS, TEES, SPECIAL SECTIONS AND CONCRETE REINFORCING BARS

WIRE PRODUCTS

RODS, WIRE, PLAIN, BLACK, COPPERED AND GALVANIZED, WELDING WIRE, NAIL WIRE, GALVANIZED BARBED WIRE, NAILS, STAPLES, HOOPS

YOUNGSTOWN BUCKEYE CONDUIT

A RIGID STEEL FULL WEIGHT CONDUIT,—HOT DIPPED GALVANIZED ELECTRO GALVANIZED, OR BLACK ENAMELED, COUPLINGS AND ELBOWS

YOUNGSTOWN ELECTRICAL METALLIC TUBING

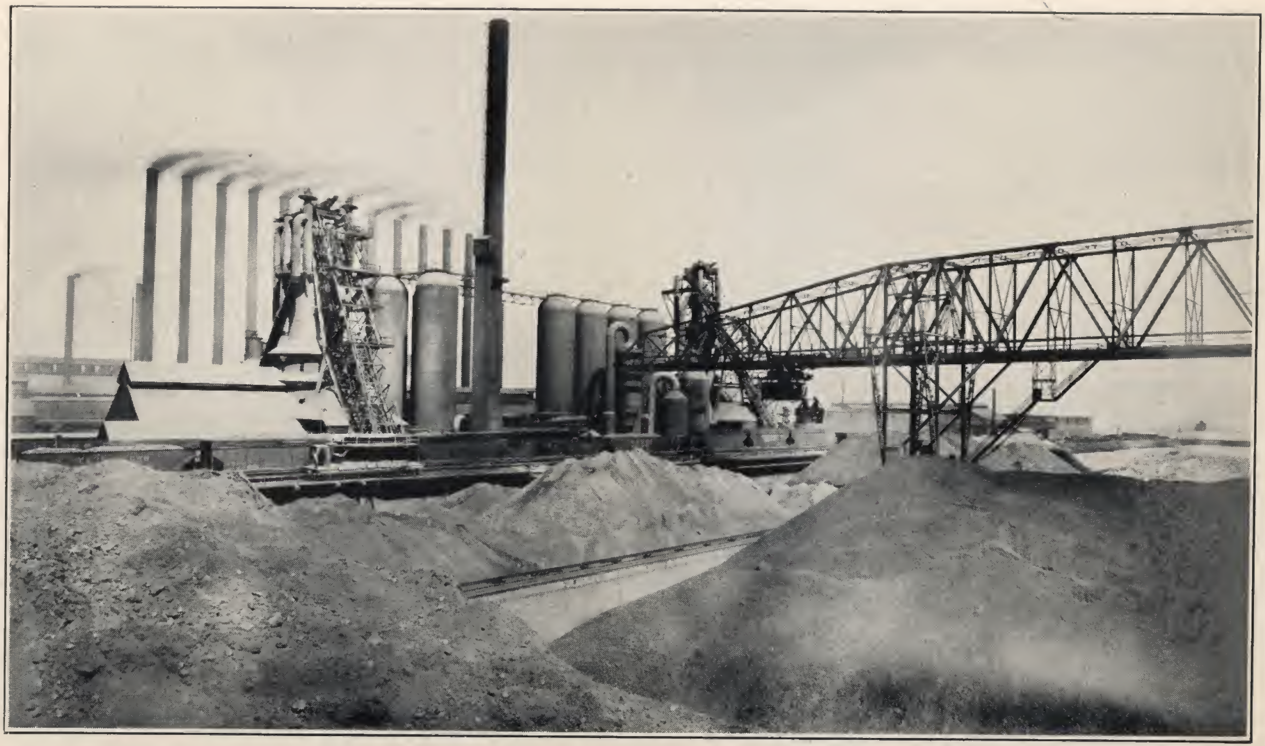
ANNOUNCEMENT

Due to an unprecedented demand, it has been found necessary to publish the fifth edition of this book, which has been prepared as a special service to all those interested in rigid steel electrical conduit.

YOUNGSTOWN BUCKEYE CONDUIT is manufactured from the Ore to the finished product entirely by one organization. We make the iron, convert it into steel, and manufacture the pipe on our own Tube Mills. We select the steel which is most suitable for Conduit pipe on account of its ductility, excellence of welding qualities, and other features that are essential to the highest grade of Conduit.

In finishing YOUNGSTOWN BUCKEYE CONDUIT, every care and facility that could possibly add to its quality are used. The inspection is rigid, being made not only by our own Inspection Department, but also by a representative of the Underwriters Laboratories, Inc., and not a length of Youngstown Buckeye Conduit is shipped that has not been approved by both. Whether Youngstown Buckeye Conduit is Black Enameled, Electro-galvanized or Hot Dipped Galvanized, it always meets the severest tests and specifications, and has been used on many of the very important jobs in this country and abroad.

In addition to useful tables and engineering data, we have included a brief description of the manufacture of Conduit from the ore to the finished product.



View of one of the Blast Furnaces and Ore Storage

SALES CONDITIONS

Sales are subject to fires, strikes, disputes with workmen, floods, accidents, embargoes, delays in transportation, shortage of cars, shortage of fuel or other material, shortage of labor, and to any other causes beyond reasonable control of the Manufacturer or Seller.

The acceptance of any order or specification and terms of payment on all sales and orders are subject to the approval of the Treasurer of the Seller. All sales contracts become effective only when approved and accepted in writing by the home office.

If the Buyer fail to fulfill the terms of payment under this or any other order between the Buyer and the Seller, or between the Buyer and The Youngstown Sheet and Tube Company, the Seller may defer further shipments until such payments are made, or may, at its option, cancel this order. The Seller reserves the right, even after partial shipment on account of any order, to require from the Buyer satisfactory security for performance of the Buyer's obligations, and refusal to furnish such security will entitle the Seller to suspend shipments until such security is furnished, and, at its option, to cancel the order.

All material claimed to be defective shall be held subject to inspection by the Seller. Claims for shortage or deductions for erroneous charges must be presented within thirty (30) days after receipt of the goods or they will not be allowed. No material will be taken back and credited or replaced unless arrangements for such return previously have been made.

The only warranty that is given by the Seller or Manufacturer is to replace such goods as prove defective, or allow credit for such goods, at its option; no claim for damages, beyond the price of the defective pieces, or for labor, will be allowed by the Seller or Manufacturer, nor will the Seller or the Manufacturer be subject to any other or further liability. If goods appear defective their use should be discontinued and the Seller notified promptly, so the matter may be investigated without delay. All tubular goods are furnished in accordance with pipe trade customs as printed on the Manufacturer's or Seller's latest basing discount cards.

Material shall be subject to Seller's or Manufacturer's standard variations for rolling and shearing, and to the Seller's or Manufacturer's standard manufacturing variations, classifications and extras. All goods made to special specification must be inspected and accepted before shipment is made.

There are no understandings or agreements relative to this contract that are not fully expressed herein, and no change shall be made in this contract unless reduced to writing and signed by both parties.

Forbearance or failure of the Seller to enforce any of these Conditions or to exercise any right accruing from any default of the Buyer shall not affect or impair the Seller's rights in case such default continue, or in case of any subsequent default of the Buyer, and such forbearance or failure will not act as a waiver in case of other or future defaults of the Buyer.

Contracts shall be construed and determined according to the laws of the State of Ohio.

Any tax imposed by any Federal Law on the sale of articles made or sold by this company shall be in addition to the sales price thereof.

FACTS WORTH KNOWING ABOUT ELECTRICAL CONDUIT

Among those responsible for the safety, efficiency and durability of electrical light and power installations, it is now an almost universal practice to insist upon the use of some form of steel protection to the wiring. The most approved form of such protection is, of course, rigid steel conduit, which not only protects wiring from injury by any of the numerous factors that menace its safety and durability, but also guards it against tampering by amateurs, a danger which is accentuated in dwellings by the rapid increase in the use of electrical appliances on circuits not intended to carry the necessary loads, and which often involves serious menace to both life and property.

Rigid steel conduit is now used in practically all commercial buildings and all residences of the better type, and it is required in basements of dwellings in most of the cities of this country. It is, of course, used in all modern power plants and industrial structures, and in all installations where protection and permanency is demanded.

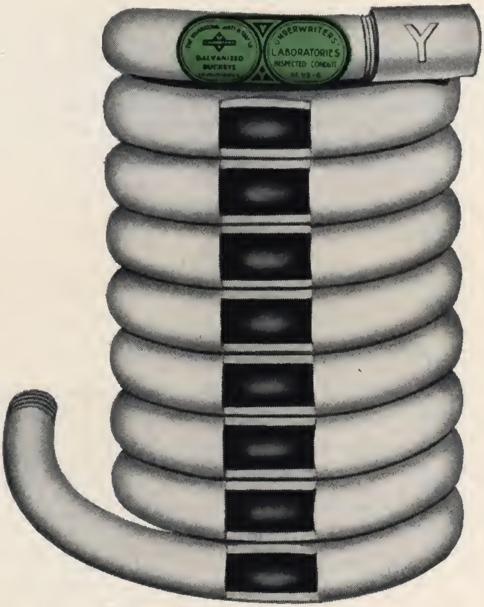
As in all other lines, there have been substitutes for rigid steel conduit devised, with the purpose of cheapening installations, but these are seldom used in permanent construction, although they may meet requirements on temporary work.

In choosing electrical conduit, care is important. All brands of conduit are sold at practically the same price, but there is, as in everything else, a wide difference in quality, although there is little difference in external appearance.

The principal features of good electrical conduit are good steel, thorough welding and ductility, tough and durable enamel, good galvanizing, and well designed, carefully cut and adequately protected threads in couplings as well as the pipe itself.

In properly made conduit, the threads are so cut that the pipe forms a practically continuous raceway for the wires, through which these wires can be drawn without injury to their covering. To secure a good raceway and at the same time provide a thoroughly firm joint requires extreme care in threading.

Not less essential is thorough enameling or galvanizing, for on this depends not only the ease with which wires may be fished through conduit during their installation, but also to a considerable extent its non-conductivity, and its durability under conditions tending to promote corrosion, which are often encountered in modern construction.



The most important feature of good electrical conduit is, however, high quality in the pipe from which it is made. It goes without saying that electrical conduit requires a superior grade of pipe, and it follows that, while such pipe may be secured in the open market, the special qualities demanded in it make dependence on such a source of supply hazardous. It also follows that a manufacturer who can select from the output of a large number of mills under his own control the pipe used for conversion into this material has an immense advantage in the production of conduit of a high and consistent quality.

Probably next in importance is the protective coating employed inside and outside of conduit. The purpose of this coating is three-fold. It protects the metal from corrosion and at the same time provides a smooth surface over which wires or cables may be drawn through the conduit without difficulty or injury to their covering, and it adds to the insulation of the wires or cables. There are many formulas for enamel, and numerous ways of applying it. Likewise there are several different methods of applying zinc coatings, all of which are not equally dependable.

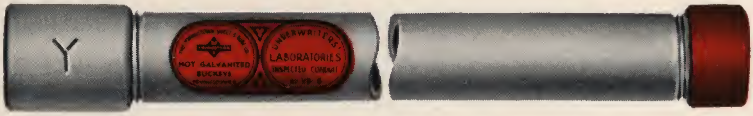
Standard specifications require that enamel and zinc coatings pass certain tests, and most of the conduit marketed will pass these tests in a more or less satisfactory manner. However, really first-class conduit will stand tests more severe than required by the average codes without its protective coating suffering injury.

Dependable galvanizing is a highly important consideration, especially since conduit is often subject to corrosive conditions, and any injury to it usually means ruin for the whole circuit, if not danger to life or property.

In like manner, thoroughly good enameling protects both the wires and the conduit itself. Youngstown Buckeye is protected by a heavy enamel which does not flake or crack from bending or rough usage and forms an insurance against injury to both wiring and conduit.

TRAVELLING CAR DUMPER
This machine will unload approximately 300 carloads
of iron ore per day.

YOUNGSTOWN
BUCKEYE CONDUIT
AND E.M.T.



HOT GALVANIZED

GALVANIZED

BLACK ENAMELED

ELECTRICAL METALLIC TUBING

Protecting The Wiring For
Future Generations

YOUNGSTOWN BUCKEYE CONDUIT

Black Enameled, Electro Galvanized and Hot Dipped Galvanized

CONDUIT

SIZE	Price Per Foot	Weight Per Foot	DIAMETERS		Thick- ness	Threads per in.
			External	Internal		
¼	$ .08½	.425	.540	.364	.088	18
⅜	.08½	.568	.675	.493	.091	18
½	.08½	.852	.840	.622	.109	14
¾	.11½	1.134	1.050	.824	.113	14
1	.17	1.684	1.315	1.049	.133	11½
1¼	.23	2.281	1.660	1.380	.140	11½
1½	.27½	2.731	1.900	1.610	.145	11½
2	.37	3.678	2.375	2.067	.154	11½
2½	.58½	5.819	2.875	2.469	.203	8
3	.76½	7.616	3.500	3.068	.216	8
3½	.92	9.202	4.000	3.548	.226	8
4	1.09	10.889	4.500	4.026	.237	8
4½	1.27	12.642	5.000	4.506	.247	8
5	1.48	14.810	5.563	5.047	.258	8
6	1.92	19.185	6.625	6.065	.280	8

SIZE	COUPLINGS		ELBOWS			
	Price Each	Wt. per 100 in lbs.	Price Each	Wt. per 100 in lbs.	Radius Inches	Inches Offset
¼	$ .05	6.0	$ .19	41	3.850	6.375
⅜	.06	9.5	.19	55	3.917	6.437
½	.07	11.6	.19	82	4.000	6.500
¾	.10	20.9	.25	109	4.500	7.250
1	.13	34.3	.37	201	5.750	8.625
1¼	.17	53.5	.45	313	7.250	10.000
1½	.21	74.3	.60	441	8.250	11.000
2	.28	120.8	1.10	707	9.500	13.625
2½	.40	172.0	1.80	1411	10.500	15.687
3	.60	249.8	4.80	1850	13.000	17.750
3½	.80	424.1	10.60	2979	15.000	20.000
4	1.00	474.1	12.25	3528	16.000	21.312
4½	1.50	550.0	18.55	4310	18.000	23.500
5	1.65	700.0	25.75	6575	24.000	29.000
6	2.40	750.0	32.00	9645	30.000	36.500

All weights and dimensions are nominal.

Conduit furnished in 10 foot lengths over all including coupling.

Conduit pipe is known and spoken of by its nominal inside diameter.

Prices quoted on Special Sizes, Bends and Lengths on application. All weights are subject to the usual variation of 5 per cent.

Every piece of conduit is carefully tested, examined and labeled, but as it is impossible to always detect imperfections, the only guarantee that is given is to replace such goods as prove defective.

Prices subject to change without notice.

BUCKEYE CONDUIT ELBOWS

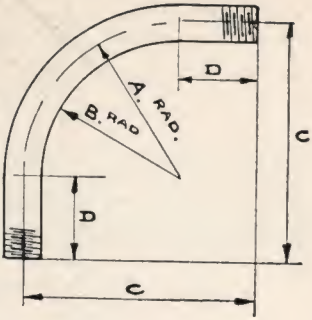


TABLE OF APPROXIMATE DIMENSIONS AND WEIGHTS
Standard Elbows 90° radius
Special radius elbows furnished upon order.

Use radius A in specifying or ordering

Nominal Inside Dia.	Actual Inside Dia.	Actual Outside Dia.	A.	B.	C.	D.	Weight Each in Lbs.	Weight per 100 in Lbs.
¼″	.36″	.54″	3.850″	3.580″	6.375″	2.500″	.41	41
⅜″	.49″	.675″	3.917″	3.580″	6.437″	2.500″	.55	55
½″	.62″	.84″	4.000″	3.580″	6.500″	2.500″	.82	82
¾″	.82″	1.05″	4.500″	3.975″	7.250″	2.750″	1.09	109
1 ″	1.04″	1.315″	5.750″	5.092″	8.625″	2.875″	2.01	201
1¼″	1.38″	1.66″	7.250″	6.420″	10.000″	2.750″	3.13	313
1½″	1.61″	1.90″	8.250″	7.300″	11.000″	2.750″	4.41	441
2 ″	2.06″	2.375″	9.500″	8.312″	13.625″	4.125″	7.07	707
2½″	2.46″	2.875″	10.500″	9.062″	15.687″	5.187″	14.11	1411
3 ″	3.06″	3.50″	13.000″	11.250″	17.750″	4.750″	18.50	1850
3½″	3.54″	4.00″	15.000″	13.000″	20.000″	5.000″	29.79	2979
4 ″	4.02″	4.50″	16.000″	13.750″	21.312″	5.312″	35.28	3528
4½″	4.50″	5.00″	18.000″	15.500″	23.500″	5.500″	43.10	4310
5 ″	5.04″	5.563″	24.000″	21.218″	29.000″	5.000″	65.75	6575
6 ″	6.06″	6.625″	30.000″	26.687″	36.500″	6.500″	96.45	9645

ELECTRICAL
TRADE MARK
YOUNGSTOWN
METALLIC TUBING

Youngstown Electrical Metallic Tubing is manufactured of high grade steel which has been specifically manufactured to standards which assure maximum welding characteristics and ductility. The steel is first rolled into strip then formed into a tube and the seam electrically welded. The wall thicknesses, diameters and circumferences are unusually uniform. These features assure efficient and labor saving installations.

On the external surfaces of all E. M. T. there is deposited a protective coating of pure zinc by the electro-galvanic process. This coating is uniform throughout and will withstand bending of the tubing without fracturing of the zinc coating. On the inside of the tubing there is baked a tough, elastic coating of black enamel which not only forms a mirror-smooth raceway through which wires may be fished with ease but which serves as an efficient insulator for the wiring system.

After the special zinc coating and the internal black enamel have been applied the tubing is given a coating, both externally and internally, of transparent enamel which serves as an additional protection.

WEIGHTS AND DIMENSIONS ARE NOMINAL

ELECTRICAL METALLIC TUBING — ELBOWS

		DIAMETER						
Size	Approx. weight 1000 ft.	Inter-nal	Exter-nal	Ft. Per Bdl.	Size	weight Per 100 in lbs.	Radius Inches	Offset Inches
½″	321	.622	.706	100	½″	------	--------	----------
¾″	488	.824	.922	50	¾″	------	--------	----------
1″	711	1.049	1.163	50	1″	100	5.750	8.625
1¼″	985	1.380	1.508	50	1¼″	150	7.250	10.000
1½″	1141	1.610	1.738	50	1½″	200	8.250	11.000
2″	1470	2.067	2.195	30	2″	275	9.500	13.625

E.M.T. furnished in 10 foot lengths, without coupling.

E.M.T. is known and spoken of by its nominal inside diameter.

Prices quoted on Special sizes, Bends and Lengths on application. All weights are subject to the usual variations.

Every piece of E.M.T. is carefully tested, examined and labeled, but as it is impossible to always detect imperfection, the only guarantee that is given is to replace such goods as prove defective.

RIGID CONDUIT INDUSTRY STANDARD
for
STANDARD RIGID STEEL CONDUIT

(ENAMELED)

A. DEFINITIONS.

A-1. Rigid Steel Conduit. Rigid steel conduit is a raceway specially constructed for the purpose of pulling in or withdrawing of wires or of cables after the conduit is in place, and made of mild steel pipe of standard weight and thickness permitting cutting standard threads, that has been cleaned of scale and rust, and has enamel or metallic corrosion-resistant coatings.

A-2. Coupling. A rigid steel conduit coupling is a short hollow steel cylinder internally threaded and intended to connect two adjacent lengths of rigid steel conduit.

A-3. Elbow. An elbow is a short curved piece of threaded rigid steel conduit of minimum standard radius serving to connect two lengths of conduit which are at an angle to one another.

Note: The term "elbow" is usually applied when the angle is 90° but may be applied for angles as small as 15°.

A-4. Fittings. Conduit fittings are the accessories necessary for the completion of a conduit system, such as boxes, elbows, bushings, and access fittings.

A-5. Nipples. Nipples shall be made from straight lengths of the same grade of tubing as rigid steel conduit; shall be treated, coated, threaded, etc., in every way according to the requirements for rigid steel conduit in so far as they apply; and shall not exceed two feet in length.

A-5a. Each lot of 100 nipples shall weigh not less than the number of pounds determined by the formula:

$$W = 100\,LA - B.$$

Where

W = Weight of 100 nipples in pounds.
L = Length of one nipple in inches.
A = Weight of nipple per inch in pounds.
B = Weight in pounds lost in threading 100 nipples.

A-5b. Values for A and B for the various trade sizes are as follows:

Trade Size of Conduit in Inches	A	B
½	0.065	2
¾	.090	4
1	.125	9
1¼	.164	10
1½	.202	11
2	.269	14
2½	.430	60
3	.561	70
3½	.663	90
4	.786	115
4½	.927	145
5	1.060	170
6	1.410	200

Example—The minimum weight of a lot of 100 14 inch nipples of the 1½ inch trade size will be 100×14×0.202—11=272 lb.

B. SCOPE

B-1. These specifications cover rigid steel conduit designed and manufactured for use as a metal raceway for the installation of wires and cables in accordance with the rules of the National Electrical Code.

C. SIZES.

C-1. Rigid steel conduit shall be furnished in electrical trade sizes, as listed in Table 1, paragraph E-5 of this standard.

D. MATERIAL AND WORKMANSHIP.

D-1. Tube. Each tube used in the manufacture of rigid steel conduit shall be of mild steel, and shall have a circular cross section sufficiently accurate to permit the cutting of clean, true threads.

D-2. Welding. All seams shall be thoroughly welded.

D-3. Cleaning of Tubes. Tubes shall be thoroughly cleaned before the application of the enamel coating. The cleaning process shall leave the surfaces of the tube in such a condition that the enamel coating will be firmly adherent and will have a smooth finish. The cleaning process shall not reduce the tube so that the weight of the finished conduit will be less than the required minimum as given in Table 1, paragraph E-5.

E. DETAIL REQUIREMENTS.

E.-1 Enamel Coating. The inside and outside surfaces of each tube shall be protected against corrosion by a coating of enamel. The character and appearance of the coating on the inside surface shall be such that the conduit can be readily distinguished its entire length from ordinary pipe commonly used for other than electrical purposes. The enamel coating on the inside and outside surfaces of the finished conduit shall have an even and smooth appearance and be of a uniform quality at all points of the length of the tube.

E-2. Threading and Reaming. Each length of conduit shall be threaded on both ends and each end shall be reamed to remove burrs and sharp edges formed by the cutting-off tool.

E-2a. If threads are cut before the enamel coating is applied, the surplus coating shall be removed from the threads, after coating.

E-2b. If threads are cut after the enamel coating is applied, the threads shall be treated with a protective coating to prevent corrosion. Such treatment of threads shall not interrupt the electrical continuity through couplings or fittings after the installation.

E-3. Couplings. Couplings shall be protected against corrosion in the same manner in which the conduit is protected. At least one coupling shall be furnished assembled with each length of conduit. Any surplus coating shall be removed from the threads so that such surplus coating will not be forced into the raceway upon assembly.

E-4. Marking. Each length of conduit shall be labeled with an Underwriters' Laboratories' label showing the manufacturer's name and/or trade-mark. This label shall also indicate to the user that the protective coating is enamel.

E-5. Length, Weight, and Wall Thickness. The length without couplings, minimum weight with couplings, and nominal wall thickness of finished conduit shall be as indicated in the following table:

TABLE 1.

Nominal Electrical Trade Size (Inches)	Nominal Diameter (Inches)		Nominal Wall Thickness (Inches)	Length without Couplings		Minimum Weight of 10 Unit Lengths with Couplings Attached (Pounds)
	Inside	Outside		Feet	Inches	
¼	0.364	0.540	0.088	9	11½	38.5
⅜	.493	.675	.091	9	11½	51.5
½	.622	.840	.109	9	11½	79.
¾	.824	1.050	.113	9	11½	105.
1	1.049	1.315	.133	9	11½	153.
1¼	1.380	1.660	.140	9	11	201.
1½	1.610	1.900	.145	9	11	249.
2	2.067	2.375	.154	9	11	334.
2½	2.469	2.875	.203	9	10½	527.
3	3.068	3.500	.216	9	10½	690.
3½	3.548	4.000	.226	9	10	831.
4	4.026	4.500	.237	9	10	982.
4½	4.506	5.000	.247	9	10	1150.
5	5.047	5.563	.258	9	9	1344.
6	6.065	6.625	.280	9	9	1770.

At least one coupling shall be furnished with each length of conduit, and the length of finished conduit, including coupling, shall be ten feet.

E-5a. A tolerance of plus or minus ¼ inch is applicable to the required length in each size.

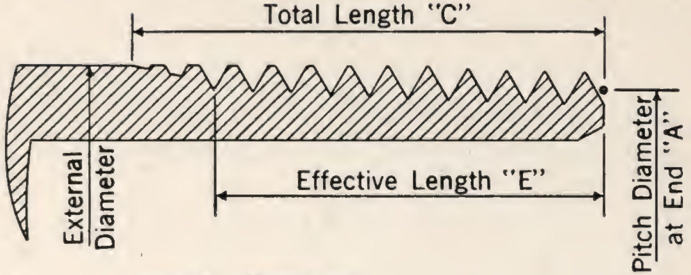
E-5b. The minimum wall thickness shall not be more than 12.5 per cent under the wall thickness specified in Table 1.

E-5c. For nominal trade sizes 1½ inch and smaller, the outside diameter at any point shall not vary more than 1/64 inch over nor more than 1/32 inch under the dimension specified in Table 1. For sizes 2 inch and over the outside diameter shall not vary more than one per cent over or under the dimensions specified in Table 1.

E-6. Threads. The pitch and form of threads shall conform to the American (Briggs) Standard for Pipe Threads. The number of threads per inch and the length of the threaded portion at each end of each length of conduit shall be as shown in Table 2.

TABLE 2.

Threads of Rigid Steel Conduit



THREAD DIMENSIONS

Nominal Electrical Trade Size (In.)	Nominal Total Length "C"		Nominal Effective Length "E"		Nominal Pitch Diameter End of Pipe "A" (Inches)	No. Threads Per Inch	Nominal Taper Per Foot on Diameter (In.)
	Decimal (Inches)	Nearest Fraction (Inches)	Decimal (Inches)	Nearest Fraction (Inches)			
¼	.5684	9/16	.4018	7/16	.4774	18	⅜
⅜	.5744	9/16	.4078	7/16	.6120	18	⅜
½	.7480	¾	.5337	½	.7706	14	⅜
¾	.7600	¾	.5457	9/16	.9813	14	⅜
1	.9436	15/16	.6828	11/16	1.2136	11½	¾
1¼	.9676	1	.7068	11/16	1.5571	11½	¾
1½	.9843	1	.7235	¾	1.7961	11½	¾
2	1.0174	1	.7565	¾	2.2690	11½	¾
2½	1.5125	1½	1.1375	1⅛	2.7195	8	¾
3	1.5750	1 9/16	1.2000	1 3/16	3.3406	8	¾
3½	1.6250	1⅝	1.2500	1¼	3.8375	8	¾
4	1.6750	1 11/16	1.3000	1 5/16	4.3344	8	¾
4½	1.7250	1¾	1.3500	1⅜	4.8313	8	¾
5	1.7813	1 13/16	1.4063	1 7/16	5.3907	8	¾
6	1.8875	1⅞	1.5125	1½	6.4461	8	¾

E-6a. Thread Tolerances. For conduit up to and including 2″ nominal size, the threaded portion shall not vary from the above standards by more than one and one-half turns either way when tested with a standard working gauge.

For conduit over 2″ nominal size, the threaded portion shall not vary from the above standards by more than one turn either way when tested with a standard working gauge.

E-6b. Taper and Threads. The perfect thread on conduit shall be tapered for its entire length. The taper of threads for sizes ¼ inch to ¾ inch inclusive shall be ⅜ inch per foot and for sizes 1 inch and larger, shall be ¾ inch per foot.

E-6c. Couplings. Couplings may be tapped straight or tapered.

E-7. Elbows and Nipples. Conduit elbows and nipples shall be made from the same grade of tubing as rigid steel conduit and shall be treated, protected, threaded, labeled, etc., in every way according to the requirements for rigid steel conduit in so far as they apply. The dimensions of 90° elbows shall be as indicated in the following Table 3.

Tolerances

Radius + ¼″ — 0 — Sizes up to 2″ inclusive.

Radius + ½″ — 0 — Sizes larger than 2″.

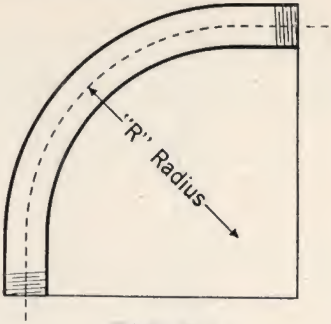


TABLE 3.

Dimensions for 90° Conduit Elbows

Trade Size of Conduit in Inches	Radius to Center of Tube "R" in Inches
½	4
¾	4½
1	5¾
1¼	7¼
1½	8¼
2	9½
2½	10½
3	13
3½	15
4	16
4½	18
5	24
6	30

E-8. Fittings. Conduit fittings shall be treated, protected, threaded, etc., in every way according to the requirements for rigid steel enameled conduit, in so far as they apply.

F. INSPECTION AND TESTS.

F-1. Inspection. Inspection shall be made at the place of manufacture or point of shipment. All finished rigid steel conduit shall be inspected visually, on both the inside and outside surfaces, to insure satisfactory workmanship.

F-2. All rigid steel conduit shall be manufactured under the supervision of the Underwriters' Laboratories' Factory Inspection Label Service and each finished length shall bear the official label of that organization. Conduit so labelled will be acceptable under these specifications.

Should the purchaser elect to subject conduit to inspection other than that made by Underwriters' Laboratories, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the conduit ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the conduit is being furnished in accordance with these specifications.

F-3. Number of Tests. One each of the tests specified in paragraphs F-6, F-7, F-8 and F-9 shall be made on a length representing each lot of conduit. A lot shall consist of the following number of pieces:

Size	Number of Pieces per Lot
1″ and under	1000
Over 1″, to but not including 3″	500
3″ and over	250

Tests representing fractions of a lot will be made only at the purchaser's expense.

F-4. Retests. If the results of tests of samples representing a lot do not conform to any of the requirements specified in paragraphs F-6, F-7, F-8 and F-9, retests of two additional samples shall be made, each of which shall conform to the requirements.

F-5. Rejection. If samples shall fail to comply with the requirements of paragraphs F-6 to F-9 inclusive, after retests as specified in paragraph F-4, the lot represented by the samples shall be rejected.

F-6. Bending Test. Conduit one inch trade size and smaller shall withstand being bent cold under slowly applied pressure through 90° to a radius measured from the inner edge of the bend of the conduit of six times the nominal internal diameter (as listed in Table 1) of the conduit without developing cracks or without opening the weld. The enamel coatings on the outside and inside surfaces shall be sufficiently elastic to prevent their cracking or flaking.

F-7. Knife Test. The enamel coating shall be of such nature that when a short piece is sliced from a tube by means of a sharp knife, it will come off as a unit and show a tendency to curl as the knife edge travels along the tube.

F-8. Thumb Nail Test. The enamel coating on finished conduit shall be of such a nature that when tested with the thumb nail it will feel tough and "have a body," but not feel hard and brittle. The enamel coating shall not soften perceptibly at temperatures up to 120° F.

F-9. Smashing Test. The toughness of the enamel coating shall be such that when the finished conduit is struck a fair, square, hard blow with a 10 or 12 inch piece of conduit of the same size or smaller, the coating will show an unbroken surface even when the steel surface is slightly dented or flattened by the force of the blow.

Note: All of the above tests shall be made at a minimum temperature of 60° F.

RIGID CONDUIT INDUSTRY STANDARD
for
STANDARD RIGID STEEL CONDUIT
(ZINC-COATED)

A. DEFINITIONS.

A-1. **Rigid Steel Conduit.** Rigid steel conduit is a raceway specially constructed for the purpose of pulling in or withdrawing of wires or of cables after the conduit is in place, and made of mild steel pipe of standard weight and thickness permitting cutting standard threads, that has been cleaned of scale and rust, and has enamel or metallic corrosion-resistant coatings.

A-2. **Coupling.** A rigid steel conduit coupling is a short hollow steel cylinder internally threaded and intended to connect two adjacent lengths of rigid steel conduit.

A-3. **Elbow.** An elbow is a short curved piece of threaded rigid steel conduit of minimum standard radius serving to connect two lengths of conduit which are at an angle to one another.

Note: The term "elbow" is usually applied when the angle is 90° but may be applied for angles as small as 15°.

A-4. **Fittings.** Conduit fittings are the accessories necessary for the completion of a conduit system, such as boxes, elbows, bushings, and access fittings.

A-5. **Nipples.** Nipples shall be made from straight lengths of the same grade of tubing as rigid steel conduit; shall be treated, coated, threaded, etc., in every way according to the requirements for rigid steel conduit in so far as they apply; and shall not exceed two feet in length.

A-5a. Each lot of 100 nipples shall weigh not less than the number of pounds determined by the formula:

$$W = 100\ LA - B.$$

Where

W = Weight of 100 nipples in pounds.
L = Length of one nipple in inches.
A = Weight of nipple per inch in pounds.
B = Weight in pounds lost in threading 100 nipples.

A-5b. Values for A and B for the various trade sizes are as follows:

Trade Size of Conduit in Inches	A	B
½	0.065	2
¾	.090	4
1	.125	9
1¼	.164	10
1½	.202	11
2	.269	14
2½	.430	60
3	.561	70
3½	.663	90
4	.786	115
4½	.927	145
5	1.060	170
6	1.410	200

Example—The minimum weight of a lot of 100 14 inch nipples of the 1½ inch trade size will be 100×14×0.202—11=272 lb.

B. SCOPE

B-1. These specifications cover rigid steel conduit designed and manufactured for use as a metal raceway for the installation of wires and cables in accordance with the rules of the National Electrical Code.

C. SIZES.

C-1. Rigid steel conduit shall be furnished in electrical trade sizes, as listed in Table 1, paragraph E-5 of this standard.

D. MATERIAL AND WORKMANSHIP.

D-1. **Tube.** Each tube used in the manufacture of rigid steel conduit shall be of mild steel, and shall have a circular cross section sufficiently accurate to permit the cutting of clean, true threads.

D-2. **Welding.** All seams shall be thoroughly welded.

D-3. **Cleaning of Tubes.** Tubes shall be thoroughly cleaned before the application of the zinc coating. The cleaning process shall leave the surfaces of the tube in such a condition that the zinc coating will be firmly adherent and will have a smooth finish. The cleaning process shall not reduce the tube so that the weight of the finished conduit will be less than the required minimum as given in Table 1, paragraph E-5.

E. DETAIL REQUIREMENTS.

E-1. **Zinc Coating.** The outside surface of each tube shall be thoroughly protected against corrosion by an even coating of zinc applied by the electro-galvanizing or the hot-dipping or the sherardizing process. The inside surface, if not protected by a zinc coating, must be covered by a coating of enamel, the character and appearance of which shall be such that the conduit can be readily distinguished its entire length from ordinary pipe commonly used for other than electrical purposes. The enamel coating and zinc coating of the finished conduit shall have an even and smooth appearance and be of a uniform quality at all points of the length of the tube.

E-2. **Threading and Reaming.** Each length of conduit shall be threaded on both ends and each end shall be reamed to remove burrs and sharp edges formed by the cutting-off tool.

E-2a. If threads are cut before the zinc coating is applied, the surplus coating shall be removed from the threads, after coating.

E-2b. If threads are cut after the zinc coating is applied, the threads shall be treated with a protective coating to prevent corrosion. Such treatment of threads shall not interrupt the electrical continuity through couplings or fittings after the installation.

E-3. **Couplings.** Couplings shall be protected against corrosion in the same manner in which the conduit is protected. At least one coupling shall be furnished assembled with each length of conduit. Any surplus coating shall be removed from the threads so that such surplus coating will not be forced into the raceway upon assembly.

E-4. **Marking.** Each length of conduit shall be labeled with an Underwriters' Laboratories' label showing the manufacturer's name and/or trade-mark. This label shall also indicate to the user that the primary protective coating is zinc.

E-5. Length, Weight, and Wall Thickness. The length without couplings, minimum weight with couplings, and nominal wall thickness of finished conduit shall be as indicated in the following table:

TABLE 1.

Nominal Electrical Trade Size (Inches)	Nominal Diameter (Inches)		Nominal Wall Thickness (Inches)	Length without Couplings		Minimum Weight of 10 Unit Lengths with Couplings Attached (Pounds)
	Inside	Outside		Feet	Inches	
¼	0.364	0.540	0.088	9	11½	38.5
⅜	.493	.675	.091	9	11½	51.5
½	.622	.840	.109	9	11½	79.
¾	.824	1.050	.113	9	11½	105.
1	1.049	1.315	.133	9	11½	153.
1¼	1.380	1.660	.140	9	11	201.
1½	1.610	1.900	.145	9	11	249.
2	2.067	2.375	.154	9	11	334.
2½	2.469	2.875	.203	9	10½	527.
3	3.068	3.500	.216	9	10½	690.
3½	3.548	4.000	.226	9	10	831.
4	4.026	4.500	.237	9	10	982.
4½	4.506	5.000	.247	9	10	1150.
5	5.047	5.563	.258	9	9	1344.
6	6.065	6.625	.280	9	9	1770.

At least one coupling shall be furnished with each length of conduit, and the length of finished conduit, including coupling, shall be ten feet.

E-5a. A tolerance of plus or minus ¼ inch is applicable to the required length in each size.

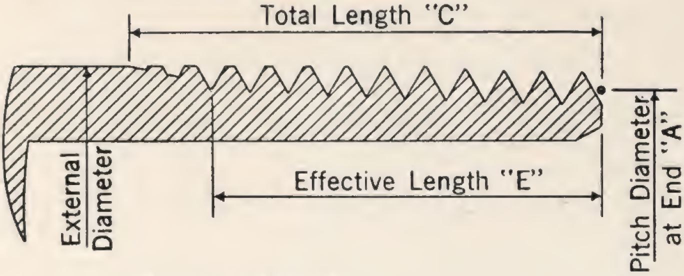
E-5b. The minimum wall thickness shall not be more than 12.5 per cent under the wall thickness specified in Table 1.

E-5c. For nominal trade sizes 1½ inch and smaller, the outside diameter at any point shall not vary more than 1/64 inch over nor more than 1/32 inch under the dimension specified in Table 1. For sizes 2 inch and over the outside diameter shall not vary more than one per cent over or under the dimensions specified in Table 1.

E-6. Threads. The pitch and form of threads shall conform to the American (Briggs) Standard for Pipe Threads. The number of threads per inch and the length of the threaded portion at each end of each length of conduit shall be as shown in Table 2.

TABLE 2.

Threads of Rigid Steel Conduit



THREAD DIMENSIONS

Nominal Electrical Trade Size (In.)	Nominal Total Length "C"		Nominal Effective Length "E"		Nominal Pitch Diameter End of Pipe "A" (Inches)	No. Threads Per Inch	Nominal Taper Per Foot on Diameter (In.)
	Decimal (Inches)	Nearest Fraction (Inches)	Decimal (Inches)	Nearest Fraction (Inches)			
¼	.5684	9/16	.4018	7/16	.4774	18	⅜
⅜	.5744	9/16	.4078	7/16	.6120	18	⅜
½	.7480	¾	.5337	½	.7706	14	⅜
¾	.7600	¾	.5457	9/16	.9813	14	⅜
1	.9436	15/16	.6828	11/16	1.2136	11½	¾
1¼	.9676	1	.7068	11/16	1.5571	11½	¾
1½	.9843	1	.7235	¾	1.7961	11½	¾
2	1.0174	1	.7565	¾	2.2690	11½	¾
2½	1.5125	1½	1.1375	1⅛	2.7195	8	¾
3	1.5750	1 9/16	1.2000	1 3/16	3.3406	8	¾
3½	1.6250	1⅝	1.2500	1¼	3.8375	8	¾
4	1.6750	1 11/16	1.3000	1 5/16	4.3344	8	¾
4½	1.7250	1¾	1.3500	1⅜	4.8313	8	¾
5	1.7813	1 13/16	1.4063	1 7/16	5.3907	8	¾
6	1.8875	1⅞	1.5125	1½	6.4461	8	¾

E-6a. Thread Tolerances. For conduit up to and including 2″ nominal size, the threaded portion shall not vary from the above standards by more than one and one-half turns either way when tested with a standard working gauge.

For conduit over 2″ nominal size, the threaded portion shall not vary from the above standards by more than one turn either way when tested with a standard working gauge.

E-6b. Taper of Threads. The perfect thread on conduit shall be tapered for its entire length. The taper of threads for sizes ¼ inch to ¾ inch inclusive shall be ⅜ inch per foot and for sizes 1 inch and larger, shall be ¾ inch per foot.

E-6c. Couplings. Couplings may be tapped straight or tapered.

E-7. Elbows and Nipples. Conduit elbows and nipples shall be made from the same grade of tubing as rigid steel conduit and shall be treated, protected, threaded, labeled, etc., in every way according to the requirements for rigid steel conduit in so far as they apply. The dimensions of 90° elbows shall be as indicated in the following Table 3.

Tolerances

Radius + ¼″ — 0 — Sizes up to 2″ inclusive.

Radius + ½″ — 0 — Sizes larger than 2″.

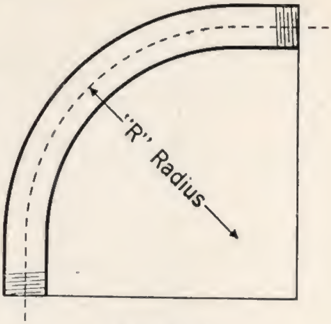


TABLE 3.

Dimensions for 90° Conduit Elbows

Trade Size of Conduit in Inches	Radius to Center of Tube "R" in Inches
½	4
¾	4½
1	5¾
1¼	7¼
1½	8¼
2	9½
2½	10½
3	13
3½	15
4	16
4½	18
5	24
6	30

E-8. **Fittings.** Conduit fittings shall be treated, protected, threaded, etc., in every way according to the requirements for rigid steel zinc-coated conduit, in so far as they apply.

F. INSPECTION AND TESTS.

F-1. **Inspection.** Inspection shall be made at the place of manufacture or point of shipment. All finished rigid steel conduit shall be inspected visually, on both the inside and outside surfaces, to insure satisfactory workmanship.

F-2. All rigid steel conduit shall be manufactured under the supervision of the Underwriters' Laboratories' Factory Inspection Label Service and each finished length shall bear the official label of that organization. Conduit so labelled will be acceptable under these specifications.

Should the purchaser elect to subject conduit to inspection other than that made by Underwriters' Laboratories, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the conduit ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the conduit is being furnished in accordance with these specifications.

F-3. Number of Tests. One each of the tests specified in paragraphs F-6 and F-7a shall be made on a length representing each lot of conduit. A lot shall consist of the following number of pieces:

Size	Number of Pieces per Lot
1″ and under	1000
Over 1″, to but not including 3″	500
3″ and over	250

Tests representing fractions of a lot will be made only at the purchaser's expense.

F-4. Retests. If the results of tests of samples representing a lot do not conform to any of the requirements specified in paragraphs F-6 and F-7a, retests of two additional samples shall be made, each of which shall conform to the requirements.

F-5. Rejection. If the samples shall fail to comply with the requirements of paragraphs F-6 and F-7a after retests as specified in paragraph F-4, the lot represented by the samples shall be rejected.

F-6. Bending Test. Conduit one inch trade size and smaller shall withstand being bent cold under slowly applied pressure through 90° to a radius measured from the inner edge of the bend of the conduit of six times the nominal internal diameter (as listed in Table 1) of the conduit without developing cracks or without opening the weld. The zinc coating on the outside surface and the zinc or enamel coating on the inside surface shall be sufficiently elastic to prevent their cracking or flaking when this test is made at a minimum temperature of 60° F.

F-7. CHEMICAL TEST FOR EXTENT AND UNIFORMITY OF ZINC COATING.

F-7a. Extent and Uniformity of Zinc Coating. The zinc coating shall be of such extent, quality, and uniformity that a sample of rigid steel zinc-coated conduit will not show a fixed deposit of copper after four immersions or dips in a standard copper sulphate solution, as specified in paragraphs F-7d to F-7k, inclusive.

F-7b. Cleaning of Samples. Each sample shall be cleaned before testing, first with carbon tetrachloride or chloroform and cheese-cloth (or with a soft brush), and then thoroughly rinsed in clean water and wiped dry with clean cheese-cloth.

F-7c. If the zinc coating bears a protective organic coating (varnish, enamel, lacquer, or the like), it shall be cleaned as follows:

(a) Immerse the sample in chloroform (U.S.P.) in a suitable container. Allow to soak several minutes so as to thoroughly soften the organic coating. Remove and immediately wipe with cheesecloth. Any delay means that some of the solvent evaporates and the coating rehardens. Repeat the wiping operation until most of the coating has been removed.

(b) Then, with successive clean portions of chloroform and clean cloths, wipe and clean the sample until all the organic coating is removed and a clean cloth moistened with chloroform shows no discoloration when the sample is rubbed with it. The sample shall then be scrubbed with chloroform, using a soft bristle brush, rinsed thoroughly in clean running water and dried. Imperfect cleaning practically always produces a false indication of failure; if imperfect cleaning is suspected, then a cleaning powder such as Babbitt's shall be used.

F-7d. The Solution. The standard stock solution of copper sulphate shall consist of chemically pure copper sulphate crystals dissolved in distilled water, about in the proportion of 36 parts, by weight, of crystals to 100 parts, by weight, of distilled water. The solution shall be neutralized by the addition of an excess of chemically pure cupric oxide (Cu.O.) The presence of an excess of cupric oxide will be shown by the sediment of this reagent at the bottom of the containing vessel.

F-7e. The neutralized solution shall be filtered before using by passing through filter paper. The filtered solution shall have a specific gravity of 1.186 plus or minus 0.003 at 65° F. (reading the scale at the level of the solution) at the beginning of each test. In case the filtered solution is high in specific gravity, distilled water shall be added to reduce the specific gravity to 1.186 at 65° F. In case the filtered solution is low in specific gravity, filtered solution of a higher specific gravity shall be added to make the specific gravity 1.186 at 65° F.

F-7f. As soon as the stronger solution is taken from the vessel containing the unfiltered neutralized stock solution, additional crystals and distilled water must be added to the stock solution. An excess of cupric oxide shall always be kept in the unfiltered stock solution.

F-7g. Quantity of Solution and Size of Vessel. Conduit samples shall be tested in a glass vessel having a diameter approximately twice as great as the outside diameter of the sample to be tested. The vessel shall be filled with the standard solution to a depth sufficient to immerse 2½ inches of the sample when placed into the solution in a vertical position.

F-7h. The same solution shall not be used for more than one series of four immersions of one sample.

F-7i. Not more than one sample shall be immersed in the solution at one time.

F-7j. Temperature of Solution. The temperature of the solution shall be maintained between 62° and 68° F. at all times during the following cycle of immersions of the sample.

F-7k. Cycle of Immersions of Sample. A clean and dry sample shall be immersed in the required quantity of standard solution in accordance with the following cycle of immersions:

First.	Immerse for one minute, wash and wipe dry.
Second.	Immerse for one minute, wash and wipe dry.
Third.	Immerse for one minute, wash and wipe dry.
Fourth.	Immerse for one minute, wash and wipe dry.

After each immersion the samples shall be immediately washed in clean water having a temperature between 62° and 68° F. and wiped dry with cheese-cloth. In removing loosely adherent copper deposits, a medium bristle brush should be used rather than a cloth, which tends to rub in and burnish the deposit and may tend to give a premature indication of failure.

The complete cycle of immersions shall be made regardless of any apparent or false failure before the completion of the specified cycle of dips.

F-7l. Failure to Pass Dip Test. If, after the fourth immersion described in paragraph F-7k, there should be a fixed bright metallic copper deposit upon the sample, the sample shall be considered to have failed to pass the test. Copper deposits on the sample within one inch of the cut end shall not be considered as a failure.

STANDARD SIZES OF CONDUIT FOR THE INSTALLATION OF WIRE AND CABLE

The following tables apply only to complete conduit systems, and do not apply to short sections of conduit used for the protection of exposed wiring from mechanical injury.

TABLE 1. TWO-WIRE AND THREE-WIRE SYSTEMS

	Number of Wires in Conduit								
Size of Wire	1	2	3	4	5	6	7	8	9
	Minimum Size of Conduit in Inches								
14	½	½	½	¾	¾	1	1	1	1
12	½	½	¾	¾	¾	1	1	1	1¼
10	½	¾	¾	1	1	1	1¼	1¼	1¼
8	½	¾	1	1	1	1¼	1¼	1¼	1¼
6	½	1	1¼	1¼	1½	1½	2	2	2
5	¾	1¼	1¼	1¼	1½	2	2	2	2
4	¾	1¼	1¼	1½	2	2	2	2	2½
3	¾	1¼	1¼	1½	2	2	2	2½	2½
2	¾	1¼	1½	1½	2	2	2½	2½	2½
1	¾	1½	1½	2	2	2½	2½	3	3
0	1	1½	2	2	2½	2½	3	3	3
00	1	2	2	2½	2½	3	3	3	3½
000	1	2	2	2½	3	3	3	3½	3½
0000	1¼	2	2½	2½	3	3	3½	3½	4
200000	1¼	2	2½	2½	3	3	3½	3½	4
225000	1¼	2½	2½	3	3	3½			
250000	1¼	2½	2½	3	3	3½			
300000	1¼	2½	3	3	3½	3½			
350000	1¼	2½	3	3½	3½	4			
400000	1¼	3	3	3½	4	4			
450000	1½	3	3	3½	4	4½			
500000	1½	3	3	3½	4	4½			
550000	1½	3	3½	4	4½	5			
600000	2	3	3½	4	4½	5			
650000	2	3½	3½	4					
700000	2	3½	3½	4½					
750000	2	3½	3½	4½					
800000	2	3½	4	4½					
850000	2	3½	4	4½					
900000	2	3½	4	4½					
950000	2	4	4	5					
1000000	2	4	4	5					
1100000	2½	4	4½	6					
1200000	2½	4½	4½	6					
1250000	2½	4½	4½	6					
1300000	2½	4½	5	6					
1400000	2½	4½	5	6					
1500000	2½	4½	5	6					
1600000	2½	5	5	6					
1700000	3	5	5	6					
1750000	3	5	5	6					
1800000	3	5	6	6					
1900000	3	5	6						
2000000	3	5	6						

STANDARD SIZES OF CONDUIT
FOR THE INSTALLATION OF WIRE AND CABLE

Continued

TABLE 2. THREE-CONDUCTOR CONVERTIBLE SYSTEM

	Size of Wires		Size Conduit Electrical Trade Size in Inches
Two	14 and one	10	¾
Two	12 and one	8	¾
Two	10 and one	6	1
Two	8 and one	4	1
Two	6 and one	2	1¼
Two	5 and one	1	1¼
Two	4 and one	0	1½
Two	3 and one	00	1½
Two	2 and one	000	1½
Two	1 and one	0000	2
Two	0 and one	250000	2
Two	00 and one	350000	2½
Two	000 and one	400000	2½
Two	0000 and one	550000	3
Two	250000 and one	600000	3
Two	300000 and one	800000	3
Two	400000 and one	1000000	3½
Two	500000 and one	1250000	4
Two	600000 and one	1500000	4
Two	700000 and one	1750000	4½
Two	800000 and one	2000000	4½

TABLE 3. STAGE POCKET AND BORDER CIRCUITS, AND ELSEWHERE BY SPECIAL PERMISSION

Size of Wire	Maximum Number of Wires in Conduit					
	1 Inch	1¼ Inch	1½ Inch	2 Inch	2½ Inch	3 Inch
14	11	19	26	43	61	95
12		15	21	34	50	77
10		12	16	27	38	60
8			13	22	31	49
6					14	22

CONDUIT SIZES FOR VARIOUS WIRES AND CABLES
600 VOLTS

Size of Wire or Cable	Lead Covered—Number of Wires			
	1	2	3	4
	Size of Conduit			
18	...	...	...	...
16	...	...	...	...
14	½	¾	¾	1
12	½	1	1	1¼
10	½	1	1	1¼
9	½	1	1¼	1¼
8	½	1¼	1¼	1¼
7	¾	1¼	1¼	1½
6	¾	1¼	1¼	1½
5	¾	1¼	1¼	1½
4	¾	1¼	1½	2
3	1	1½	1½	2
2	1	1½	2	2
1	1	2	2	2½
0	1	2	2	2½
00	1¼	2	2½	2½
000	1¼	2	2½	3
0,000	1¼	2½	2½	3
200,000	1¼	2½	2½	3
250,000	1¼	2½	3	3½
300,000	1½	3	3	3½
350,000	1½	3	3	3½
400,000	1½	3	3½	3½
450,000	1½	3	3½	4
500,000	1½	3	3½	4
550,000	2	3½	4	4
600,000	2	3½	4	4
650,000	2	3½	4	4
700,000	2	3½	4	...
750,000	2	4	4½	...
800,000	2	4	4½	...
850,000 to 1,000,000	2½	4	4½	...
1,050,000 to 1,450,000	2½	...	...	...
1,500,000 to 2,000,000	3	...	...	...

CONDUIT SIZES FOR VARIOUS WIRES AND CABLES
600 VOLTS

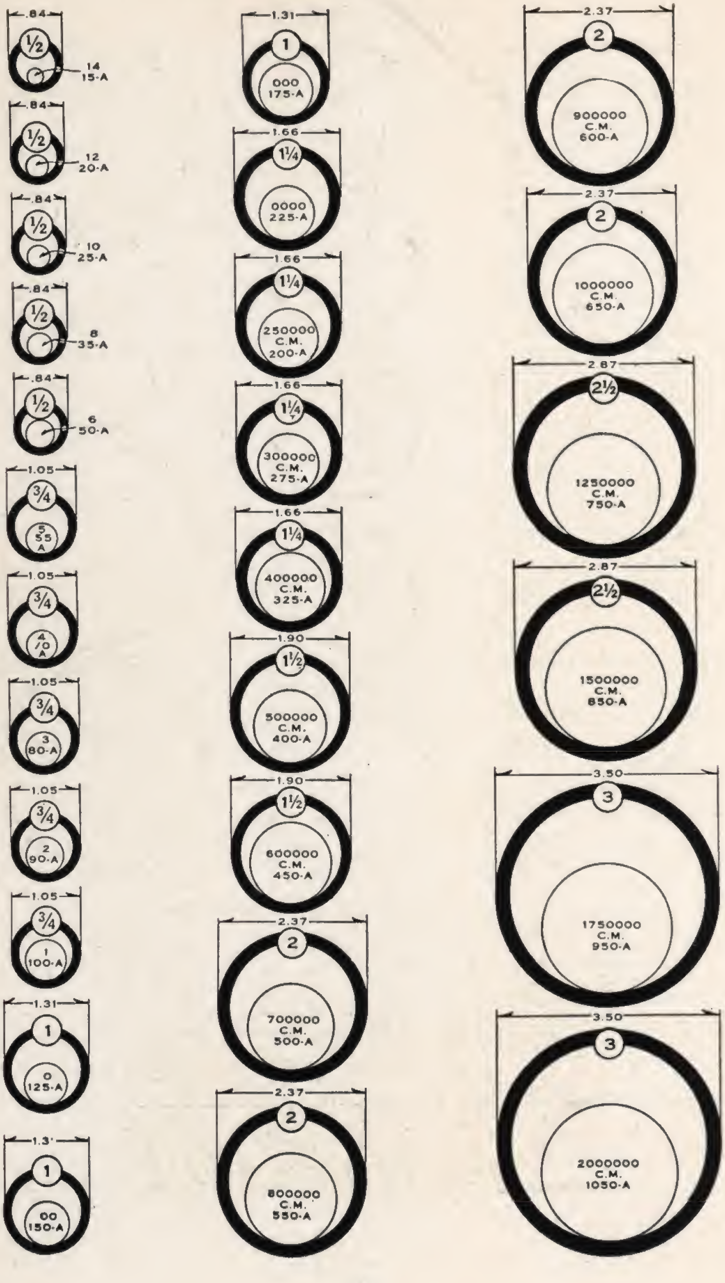
Size of Conduit	No. 14	Size of Wire No. 16* Number of Wires	No. 18*
½	3	6	10
¾	5	14	20
1	7	22	32
1¼	13	55	80
1½	18	70	100
2	30	125	170
2½	60	200	250
3	75	300	400

*Light Insulation.

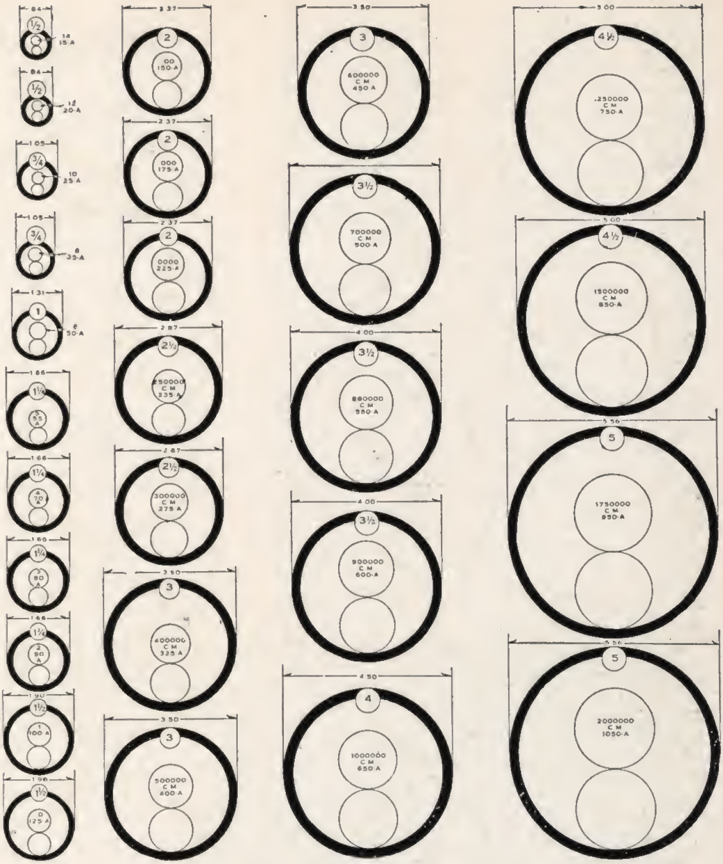
TWIN WIRES

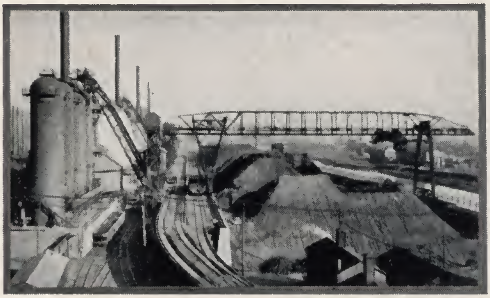
Size of Conduit	No. 14	Size of Wire No. 12 Number of Twins	No. 10	No. 8
½	1	1	..	..
¾	2	2	1	1
1	3	3	2	1
1¼	5	5	3	2
1½	8	7	5	4
2	12	10	8	6
2½	18	16	12	9
3	26	22	13	14

SINGLE WIRE SYSTEM



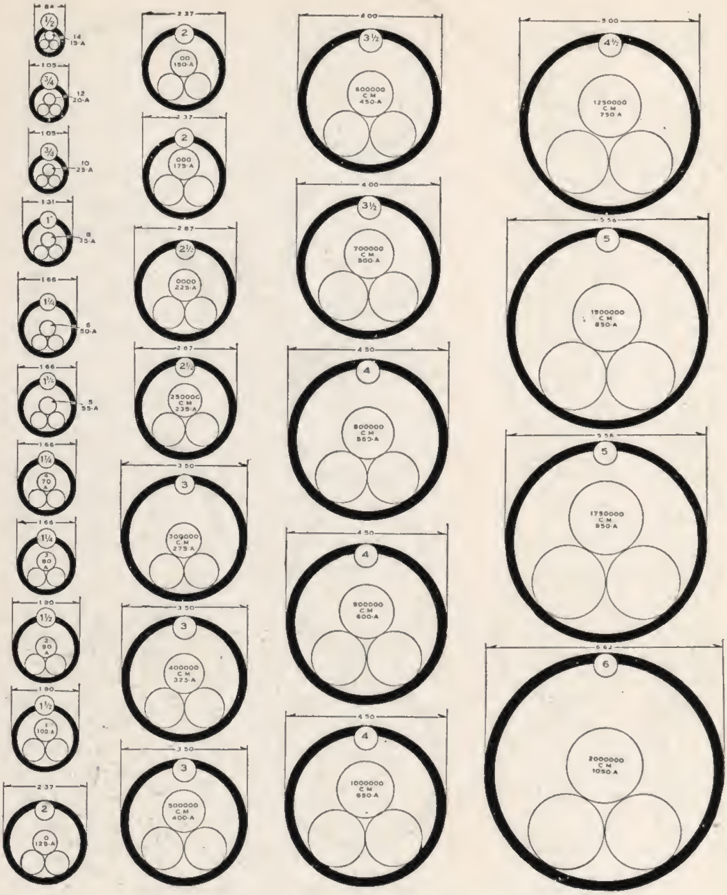
TWO WIRE SYSTEM



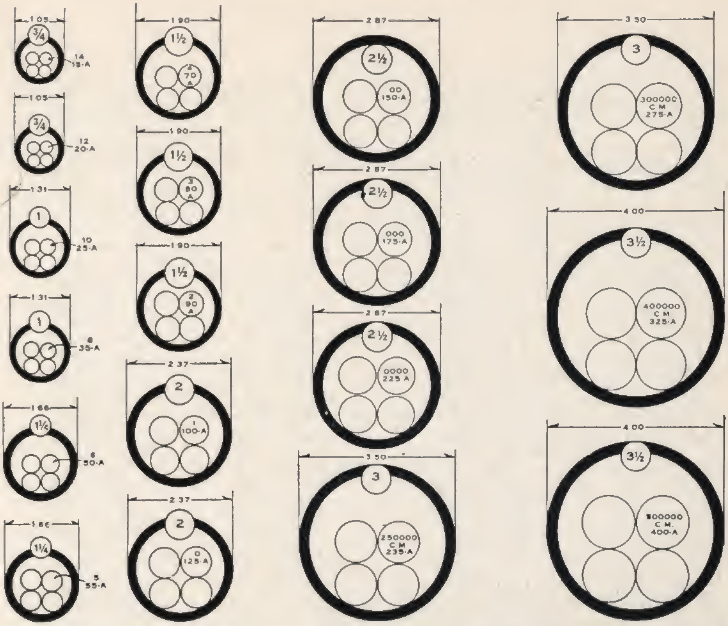


Partial view of Blast Furnace Plant at the Campbell Works

THREE WIRE SYSTEM



FOUR WIRE SYSTEM

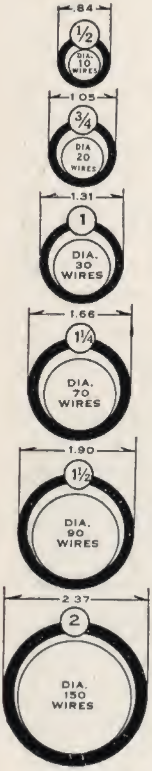


Bessemer Converter "Blowing" a heat of steel

SIGNAL SYSTEM

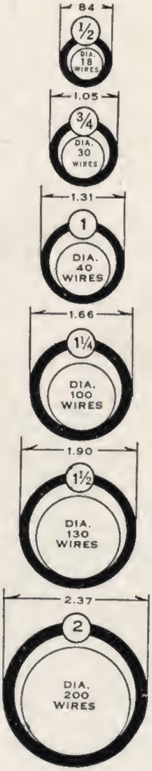
No. 16 Light Insulation Fixture Wires.

Based on Straight Run Without Elbow.



No. 18 Light Insulation Fixture Wires.

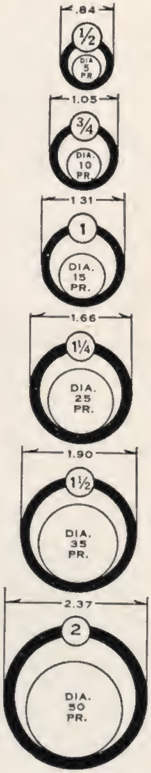
Based on Straight Run Without Elbow.



No. 20 Braided and Twisted Pair.

Switchboard or Desk Instrument Wire.

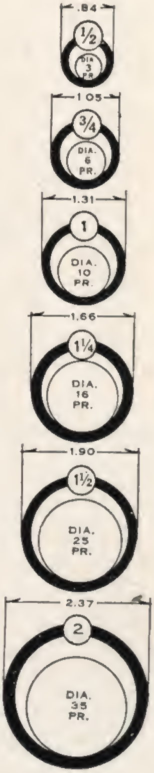
Based on not more than two 90° Elbows.



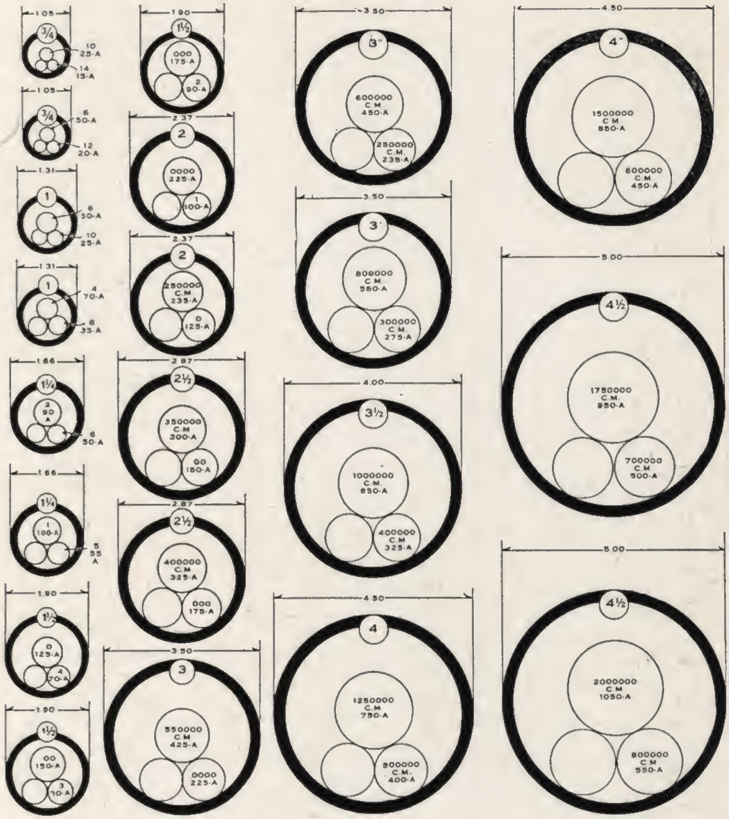
No. 19 Braided and Twisted Pair.

Standard $\frac{3}{32}$″ Insulation Telephone Wire.

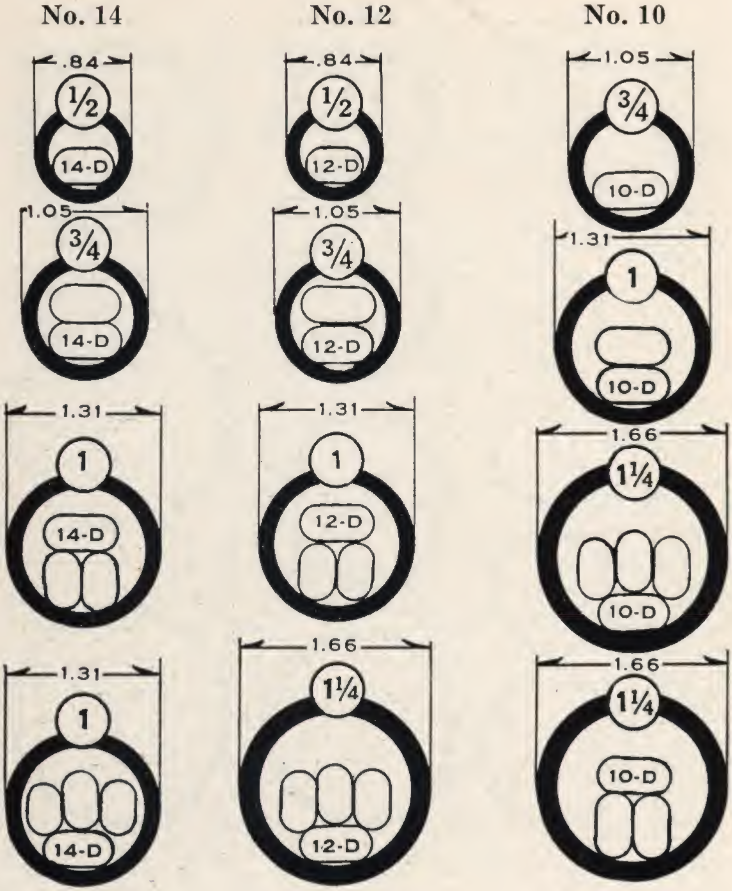
Based on not more than two 90° Elbows.

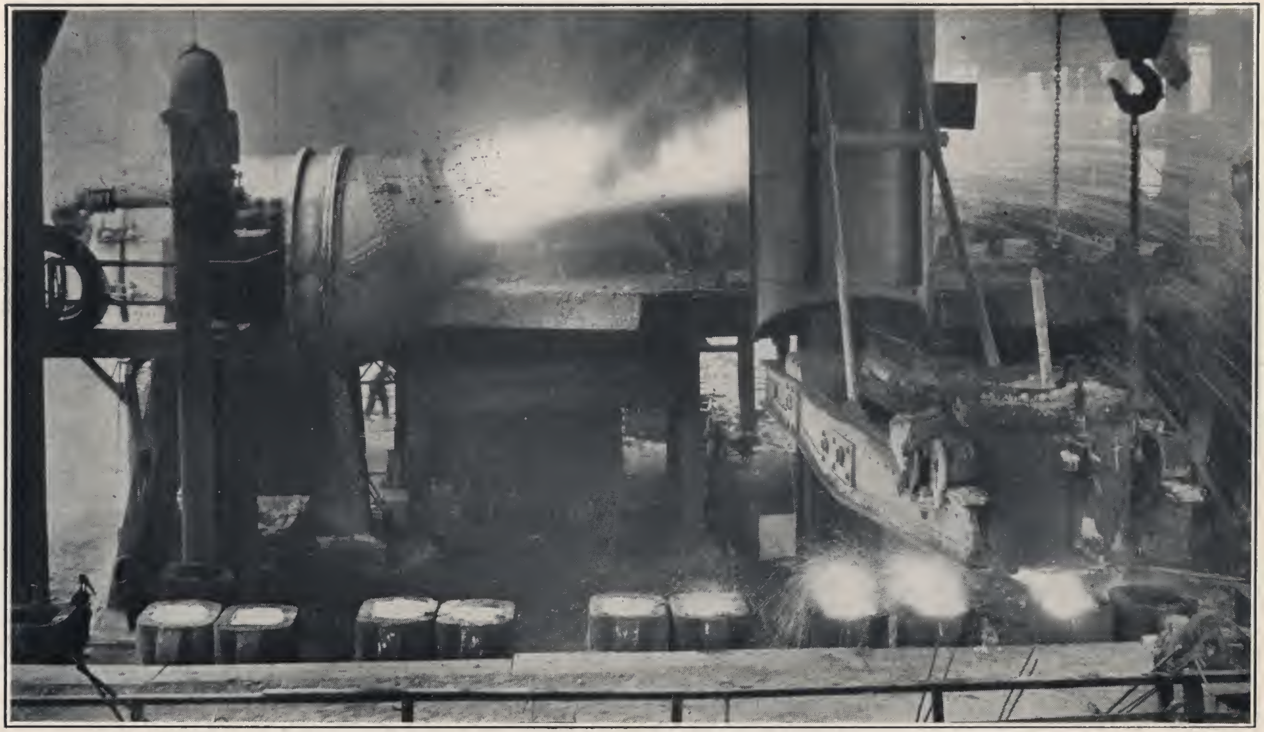


CONVERTIBLE SYSTEM



DUPLEX WIRE

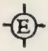
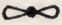
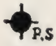
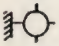
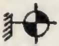
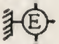
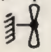
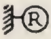
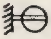
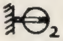
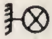

No. 14
.84
1/2
14-D
1.05
3/4
14-D
1.31
1
14-D
1.31
1
14-D
No. 12
.84
1/2
12-D
1.05
3/4
12-D
1.31
1
12-D
1.66
1¼
12-D
No. 10
1.05
3/4
10-D
1.31
1
10-D
1.66
1¼
10-D
1.66
1¼
10-D



Partial view of Interior of Bessemer Plant

STANDARD SYMBOLS FOR WIRING PLANS

As recommended and adopted by the Association of Electragists, International, The American Institute of Architects and the American Institute of Electrical Engineers, and approved by the American Engineering Standards Committee.

	Ceiling outlet.
	Ceiling outlet (gas and electric).
	Ceiling lamp receptacle. Specifications to describe type such as key, keyless or pull chain.
	Ceiling outlet for extensions.
	Ceiling fan outlet.
	Pull Switch.
	Drop cord.
	Wall bracket.
	Wall bracket (gas and electric).
	Wall outlet for extensions.
	Wall fan outlet.
	Wall lamp receptacle. Specifications to describe type such as key, keyless or pull chain.
	Single convenience outlet.
	Double convenience outlet.
	Junction box.
	Special purpose outlet. Lighting, heating and power as described in specifications.
	Special purpose outlet. Lighting, heating and power as described in specifications.
	Special purpose outlet. Lighting, heating and power as described in specifications.
	Exit light.
	Floor outlet.
	Floor elbow.
	Floor tee.
S^1	Local switch—single pole.
S^2	Local switch—double pole.
S^3	Local switch—3 way.
S^4	Local switch—4 way.
S^D	Automatic door switch.

STANDARD SYMBOLS FOR WIRING PLANS Continued

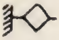
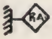
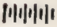
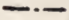
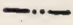
S^K	Key push button switch.
S^E	Electrolier switch.
S^P	Push button switch and pilot.
S^R	Remote control push button switch.
T.S.	Tank switch.
◎	Motor.
M.C.	Motor Controller.
▬	Lighting panel.
▨	Power panel.
◪	Heating panel.
▩	Pull box.
▥	Cable supporting box.
⊟	Meter.
▽	Transformer.
——	Branch circuit, run concealed under floor above.
- - - - -	Branch circuit, run exposed.
— —	Branch circuit, run concealed under floor.
ıı	This character marked on top circuits indicates 2 No. 14 conductors in ½-inch conduit.
ı ıı	Indicates 3 No. 14 conductors in ½-inch conduit.
ıı ıı	Indicates 4 No. 14 conductors in ¾-inch conduit unless marked ½-inch.
ı ıı ıı	Indicates 5 No. 14 conductors in ¾-inch conduit.
ıı ıı ıı	Indicates 6 No. 14 conductors in 1-inch conduit unless marked ¾ inch.
ı ıı ıı ıı	Indicates 7 No. 14 conductors in 1-inch conduit.
ıı ıı ıı ıı	Indicates 8 No. 14 conductors in 1-inch conduit.

Note.—If larger conductors than number 14 are used, use the same symbols and mark the conductor and conduit size on the run.

▬▬	Feeder run concealed under floor above.
▬ ▬ ▬ ▬	Feeder run exposed.
▬▬ ▬▬	Feeder run concealed under floor.
-o-o-	Pole line.
⊡	Push Button.

STANDARD SYMBOLS FOR WIRING PLANS

Continued

	Buzzer.
	Bell.
	Annunciator.
	Interior telephone.
	Public telephone.
	Clock (secondary).
	Clock (master).
	Time stamp.
	Electric door opener.
	Local fire alarm gong.
	City fire alarm station.
	Local fire alarm station.
	Fire alarm central station.
	Speaking tube.
	Nurse's signal plug.
	Maid's plug.
	Horn outlet.
	District messenger call.
	Watchman station.
	Watchman central station detector.
	Public telephone—PBX switchboard.
	Interconnection telephone central switchboard.
	Interconnection cabinet.
	Telephone cabinet.
	Telegraph cabinet.
	Special outlet for signal system. As described in specifications.
	Battery.
	Signal wires in conduit. Concealed under floor.
	Signal wires in conduit. Concealed under floor above.

SOME YOUNGSTOWN BUCKEYE CONDUIT INSTALLATIONS

Allied Crafts Building	Los Angeles, Calif.
Alvear Palace Hotel	Buenos Aires, Argentine
Ambassador Theatre Building	St. Louis, Mo.
American Insurance Building	Newark, N. J.
A. and I. State Normal School	Nashville, Tenn.
American Security & Trust Co. Add.	Washington, D. C.
American Thread Co.	Dalton, Ga.
Anglo-London-Paris National Bank	San Francisco, Cal.
Ashtabula Power Plant	Ashtabula, Ohio
Auditorium and Convention Hall	Grand Rapids, Mich.

Balboa Theatre	San Diego, Cal.
Bank of Mexico	Mexico City, Mexico
Banks Hantler Building	Los Angeles, Calif.
Bankers Building	Chicago, Ill.
Bankhead Hotel	Birmingham, Ala.
Barbizon Apartments	New York, N. Y.
Bassett Tower Building	El Paso, Texas
Bay Shore Colonial Hotel	Tampa, Fla.
Bendix Building	Los Angeles, Calif.
Beth Isarel Hospital	Boston, Mass.
Big Rapids Post Office	Big Rapids, Miss.
Birmingham Athletic Club	Birmingham, Ala.
Bonwit-Teller Department Store	New York, N. Y.
Bon Marche Building	Ashville, N. C.
Book-Cadillac Hotel	Detroit, Michigan
Book Tower Building	Detroit, Michigan
Boston & Albany Pass. Station	Springfield, Mass.
Boston Lying In Hospital	Boston, Mass.
Breakers Hotel	West Palm Beach, Fla.
Brighton High School	Boston, Mass.
British Embassy	Washington, D. C.
Brooklyn Eye & Ear Hospital	Brooklyn, N. Y.
Brophy College	Phoenix, Ariz.
Brown Paper Mill	Monroe, La.
G. Buehler & Co. Furniture Factory	Allentown, Pa.
Bureau of Engraving and Printing	Washington, D. C.
Byers Junior High School	Denver, Colorado

Cadillac Building	Boston, Mass.
Cahokia River Power Plant	St. Louis, Mo.
California State Building	San Diego, Cal.
California Walnut Growers Assn.	Los Angeles, Cal.
Camden County Vocational School	Camden, N. J.
Capitol Building	Springfield, Ill.
Carew Tower	Cincinnati, Ohio
Casa Loma Apartments	Kansas City, Mo.
Casualty Hospital	Washington, D. C.
Cavalier Hotel	Washington, D. C.
Cavalier Hotel	Virginia Beach, Va.
Clotex Co.	New Orleans, La.
Central Tower Building	Akron, Ohio
Central Mercantile Tower Building	New York, N. Y.

SOME YOUNGSTOWN BUCKEYE CONDUIT INSTALLATIONS

Central Terminal Building	New Orleans, La.
The Cezzanne Apartments	Kansas City, Mo.
Chestnut Hill Academy	Philadelphia, Pa.
Chicago Home School for Boys	Chicago, Ill.
Chicago Evening Post Building	Chicago, Ill.
City Service Building	New York, N. Y.
City and County Building	Phoenix, Ariz.
Cliff Hotel	San Francisco, Cal.
Ben and Jan Collins Home for Women	Texarkana, Ark.
Commerce Building	Kansas City, Mo.
Continental Building	New York, N. Y.
Corcoran Art Gallery	Washington, D. C.
Court House and Jail	Longview, Texas
Dallas Cotton Exchange Building	Dallas, Texas
Dallas National Bank Building	Dallas, Texas
Dallas Theatre	Dallas, Texas
De Paul University Building	Chicago, Ill.
Department of Agriculture	Washington, D. C.
Detroit-Leland Hotel	Detroit, Mich.
Eldorado Towers	New York, N. Y.
Elmira Reformatory	Elmira, N. Y.
El Paso County Court House	El Paso, Texas
Express Evening News Building	San Antonio, Texas
Federal Bank Building	Kansas City, Mo.
Federal Reserve Bank	Boston, Mass.
Federal Reserve Bank	Cleveland, Ohio
First Baptist Church	Winston-Salem, N. C.
First National Bank	Denver, Colo.
First National Bank	Detroit, Michigan
First National Stores	Boston, Mass.
Fisher Building	Detroit, Michigan
Garland Building	Chicago, Ill.
Garment Capitol Building	Los Angeles, Cal.
Gatesworth Hotel Apts.	St. Louis, Mo.
General Motors Building	New York, N. Y.
General Post Office	Havana, Cuba
Georgetown University	Washington, D. C.
Geo. Washington Hotel	New York, N. Y.
Gold and Company Building	Lincoln, Nebr.
Goldman Socks Co. Building	New York, N. Y.
Granada Apartment Hotel	New York, N. Y.
Grand Trunk Terminal Warehouse	Detroit, Michigan
Graybar Building	New York, N. Y.
Guardian Trust Co. Building.	Cleveland, Ohio
Harrison Morton Grade and High Sch'l	Allentown, Pa.
Harvard Physics Laboratory	Cambridge, Mass.
Harvard Dormitory	Cambridge, Mass.
Harvard Biological Building	Cambridge, Mass.

SOME YOUNGSTOWN BUCKEYE CONDUIT

INSTALLATIONS

Hilltop Manor Apts.	Washington, D. C.
Holbrook Building	San Francisco, Cal.
Holland Plaza Building	New York, N. Y.
Horace Bushnell Memorial Hall	Hartford, Conn.
Hotel Adams	Phoenix, Ariz.
Hospital and Sanitarium	Norfolk, Va.
Hotel Biltmore	Los Angeles, Cal.
Hotel Cavalier	Virginia Beach, Va.
Hotel Hilton	El Paso, Texas
Hotel Madison	Atlantic City, N. J.
Hotel Majestic	New York, N. Y.
Hotel Mayflower	Akron, Ohio
Hotel Morrison	Chicago, Ill.
Hotel New Yorker	New York, N. Y.
Hotel Onesto	Canton, Ohio
Hotel Orndorff	El Paso, Texas
Hotel Ojibway	Sault Ste. Marie, Mich.
Hotel Paramount	New York, N. Y.
Hotel Paris	New York, N. Y.
Hotel Peabody	Memphis, Tenn.
Hotel Rudolph	Atlantic City, N. J.
Hotel Sevilla-Biltmore	Havana, Cuba
Hotel Stevens	Chicago, Ill.
Hotel Statler	Boston, Mass.
Hotel Statler	St. Louis, Mo.
Hotel Waldorf-Astoria	New York, N. Y.
House of Representatives Office Bldg.	Washington, D. C.
J. L. Hudson Building	Detroit, Michigan
Internal Revenue Building	Washington, D. C.
Jefferson County Court House	Beaumont, Texas
Jefferson County Court House	Birmingham, Ala.
Jewish Theological Seminary	New York, N. Y.
John Sweets School	San Francisco, Cal.
Junior-Senior High School	Great Neck, L. I., N. Y.
Junior-Senior High School	Washington, Pa.
Kay Transit Co.	San Francisco, Cal.
Koppers Building	Pittsburgh, Pa.
Lackawanna R. R. Terminal Building	Jersey City, N. J.
Lake Side Hospital	Cleveland, Ohio
Lane Technical High School	Chicago, Ill.
Lawrenceville Infirmary	Lawrenceville, N. J.
Lehigh Valley R. R. Warehouse	New York, N. Y.
Lincoln Building	New York, N. Y.
Lindell Tower Apartments	St. Louis, Mo.
Loretta Academy	El Paso, Texas
Los Angeles Investment Building	Los Angeles, Cal.
Madison Square Garden	New York, N. Y.
Magnolia Building	Dallas, Texas
Majestic Hotel	Hot Springs, Ark.
Marcott Hotel Building	Indianapolis, Ind.

SOME YOUNGSTOWN BUCKEYE CONDUIT INSTALLATIONS

Margaret Maternity Hospital	New York, N. Y.
Marine Barracks	Quantico, Va.
Marine Hospital Addition	Detroit, Mich.
Marine Hospital	Baltimore, Md.
Masonic Temple	New Orleans, La.
Massachusetts General Hospital	Boston, Mass.
Massachusetts Institute of Technology	Boston, Mass.
Massachusetts Trust Co.	Boston, Mass.
Medical Arts Building	Fort Worth, Texas
Medium Security Prison	Woodbourne, N. Y.
Mercer Hospital	Trenton, N. J.
The Mercer Trust Co.	Trenton, N. J.
Merchandise Mart	Chicago, Ill.
Midland Bank Building	Cleveland, Ohio
Morey Junior High School	Denver, Colo.
Morton Building	Chicago, Ill.
Municipal Building	Texarkana, Ark.
Murray Body Co.	Memphis, Tenn.
Nassau Bank Building	Brooklyn, N. Y.
National Club Hotel	New York, N. Y.
National City Bank Building	Havana, Cuba
National Palace	Mexico City, Mexico
National Theatre	Mexico City, Mexico
Navarro Apartment Hotel	New York, N. Y.
New Federal Building	Tulsa, Okla.
New York Central Building	New York, N. Y.
New York Edison Power House	New York, N. Y.
New York State Roosevelt Memorial	New York, N. Y.
New York Subway	New York, N. Y.
New York Telephone Building	New York, N. Y.
Nels-Esperson Building	Houston, Texas
Non-Commissioned Officers Barracks	Ft. Sill, Okla.
North Station Terminal	Boston, Mass.
Nutley High School	Nutley, N. J.
Officers Quarters	Selfridge Field, Mich.
Officers Quarters	Ft. Benning, Ga.
Ohio Bell Telephone Co.	Akron, Ohio
Ohio Bell Telephone Co.	Cleveland, Ohio
O'neil Department Store	Akron, Ohio
Open Air Theatre	San Diego, Cal.
Orpheum Theatre	Phoenix, Ariz.
Orthopedic Hospital	Trenton, N. J.
Packard Engineering Building	Bethlehem, Pa.
Pantages Theatre	Los Angeles, Cal.
Park Central Apartment Hotel	New York, N. Y.
Patrick Henry School	San Francisco, Cal.
Paulsen Medical Dental Building	Spokane, Wash.
Penobscott Building	Detroit, Mich.
Pere Marquette Building	New Orleans, La.
Perrine Building	Oklahoma City, Okla.

SOME YOUNGSTOWN BUCKEYE CONDUIT INSTALLATIONS

Phillips Hotel	Kansas City, Mo.
Pier No. 38	Philadelphia, Pa.
Pittsfield Building	Chicago, Ill.
Plaza Theatre	El Paso, Texas
Polsky Building	Akron, Ohio
Post Dispatch Building	St. Louis, Mo.
Post Office	Alexandria, La.
Post Office	Beaumont, Texas
Post Office	Bloomfield, N. J.
Post Office	Cleveland, Ohio
Post Office	Fort Worth, Texas
Post Office	Durham, N. C.
Post Office	Lynchburg, Va.
Post Office	Minneapolis, Minn.
Post Office	Rochester, N. Y.
Post Office	Washington, D. C.
Post Office	Youngstown, Ohio
Post Office	Detroit, Mich.
Post Office	San Francisco, Cal.
Printing Center Building	Los Angeles, Cal.
Quinlan Castle Apartments	Birmingham, Ala.
Rahway Memorial Hospital	Rahway, N. J.
R.J.Reynolds Tobacco Co.Office Bldg.	Winston Salem, N. C.
Rhodes Medical Arts Tower	Tacoma, Wash.
Ritz-Carlton Hotel	Philadelphia, Pa.
Rockefeller Institute	New York, N. Y.
John A. Roebling Sons Co. Office Bldg.	Trenton, N. J.
Roger Bacon High School	St. Bernard, Cincinnati, O.
Roussiau Apartments	Kansas City, Mo.
Roxbury Memorial High School	Boston, Mass.
Roxy Theatre	New York, N. Y.
Russell Erskine Hotel	Huntsville, Ala.
Salmon Tower Building	New York, N. Y.
San Carlos Hotel	Phoenix, Ariz.
San Diego Trust and Sav. Bk. Bldg.	San Diego, Cal.
San Remo Towers	New York, N. Y.
Santa Fe Building	Amarillo, Texas
School for White Handicapped Children	Baltimore, Md.
Schroeder Hotel	Milwaukee, Wis.
Science Bldg. Huhlenberg University	Allentown, Pa.
Scottish Rite Temple	Washington, D. C.
Severance Hall	Cleveland, O.
Sherry-Netherlands Hotel	New York, N. Y.
Shoreham Office Building	Washington, D. C.
South Amboy Power Station	New York, N. Y.
South Dallas High School	Dallas, Texas
Southern Kraft Corp. (New Plant)	Panama City, Florida
Spreckels Theatre Building	San Deigo, Calif.
St. Francis Church	San Francisco, Calif.

SOME YOUNGSTOWN BUCKEYE CONDUIT INSTALLATIONS

St. Josephus Church	San Francisco, Calif.
St. Josephs Orphan Asylum	San Francisco, Calif.
St. Louis Globe Democrat	St. Louis, Mo.
St. Mary's Hospital	East St. Louis, Ill.
St. Mary's R. C. Cathedral Hospital	Trenton, N. J.
St. Lukes Hospital	Cleveland, O.
St. Lukes Hospital	San Francisco, Calif.
Stark Mills	Hogansville, Ga.
State Bank Building	Chicago, Ill.
State Bank and Trust Building	New York, N. Y.
Stephen Palmer High School	Palmerton, Pa.
Stevenson Apartments	Kansas City, Mo.
S. W. Strauss Building	Chicago, Ill.
Stock Exchange Building	Los Angeles, Cal.
Tenants Building, State Hospital	Trenton, N. J.
Texarkana Country Club	Texarkana, Ark.
Textile Center Building	Los Angeles, Cal.
The Breakers Hotel	Palm Beach, Fla.
The Capitol	Washington, D. C.
Thos. Jefferson Hotel	Birmingham, Ala.
Tower Office Building	Washington, D. C.
Tubercular Sanitorium	Oneonta, N. Y.
Union Bank Building	Chicago, Ill.
Union Department	San Diego, Cal.
Union Trust Co. Building	Cleveland, Ohio
University Club Building	Los Angeles, Cal.
University of Florida, College Bldg.	Gainesville, Fla.
University of Maryland Hospital	Baltimore, Md.
U. S. Grant Hotel	San Diego, Cal.
U. S. Mint	San Francisco, Cal.
U. S. Veterans Hospital	Fayetteville, Ark.
"Wallace S" Building	Tampa, Fla.
Walter Reed Hospital	Washington, D. C.
Ward Building Newton Hospital	Newton, Mass.
Whitney Building	Detroit, Mich.
Wilshire Tower Building	Los Angeles, Cal.
Wright Aeronautical Building	Patterson, N. J.
Yale Gymnasium	New Haven, Conn.
Y. M. C. A. Building	Akron, Ohio
Y. W. C. A. Building	Akron, Ohio
Youngstown City Hospital (New)	Youngstown, Ohio
No. 50 Broadway Building	New York, N. Y.
No. 75 Federal St.	Boston, Mass.
No. 1 Fifth Avenue Apt. Hotel	New York, N. Y.
261 Fifth Avenue	New York, N. Y.
No. 1 La Salle Street, Building	Chicago, Ill.
No. 480 Park Ave. Office Building	New York, N. Y.
No. 120 Wall Street	New York, N. Y.

UNITS OF MEASURE

The electrical units are derived from the following mechanical units of the metric system:

METER.—A unit of length equal, approximately, to one ten-millionth part of a quadrant of a meridian of the earth taken through Paris; or, approximately, to 39.37 inches.

GRAMME.—Unit of weight. Weight of a cubic centimeter of water at a temperature of 4 degrees centigrade.

SECOND.—Unit of time. The time of one swing of a pendulum making 86,400 swings in a solar day.

ELECTRICAL UNITS

VOLT.—Such an electromotive force as would cause a current of one ampere to flow against a resistance of one ohm. Such an electromotive force as would charge a condenser of the capacity of one farad with a quantity of electricity equal to one coulomb.

OHM.—The practical unit of electric resistance. Such a resistance as would limit the flow of electricity under an electromotive force of one volt, to a current of one ampere, or one-coulomb-per-second.

MEGOHM.—1,000,000 ohms.

AMPERE.—The practical unit of electric current. A rate of flow of electricity transmitting one coulomb per second. The current of electricity which would pass through a circuit whose resistance is one ohm, under an electromotive force of one volt.

COULOMB.—The practical unit of electric quantity. Such a quantity of electricity as would pass in one second through a circuit conveying one ampere. The quantity of electricity contained in a condenser of one farad capacity, when subjected to the E. M. F. of one volt.

FARAD.—The practical unit of electric capacity. Such a capacity of a conductor or condenser that one coulomb of electricity is required to produce therein a difference of potential of one volt.

MICROFARAD (MFD).—One-millionth of a farad.

WATT.—A unit of electric power. A volt-ampere. The power developed when 44.25 foot-pounds of work are done in a minute, or 0.7375 foot-pound of work is done in a second.

JOULE.—A volt-coulomb or unit of electric energy or work. The amount of electric work required to raise the potential of one coulomb of electricity one volt. Ten million ergs.

OHM'S LAW

Ohm's law is a method of expressing relationship existing between the electromotive force, current and resistance, and, is practically the basis of most electrical computations. It is expressed in various forms, as follows:

$$\text{Current Flow} = \frac{\text{Electromotive Force}}{\text{Resistance}} \text{ or, } I = \frac{E}{R}$$

Electromotive force equals the current flow multiplied by resistance.

Electromotive Force=Current Flow x Resistance, or $E=I \times R$

Resistance equals the electromotive force divided by the current flow.

$$\text{Resistance}=\frac{\text{Electromotive Force}}{\text{Current Flow}} \text{ or, } R=\frac{E}{I}$$

I=Amperes. E=Volts. R=Ohms.

Electromotive force varies directly as the current and resistance.

Resistance varies directly with the electromotive force and inversely as the current.

Current varies directly with the electromotive force and inversely as the resistance.

MIL

The "mil," whose expressed value is $\frac{\text{One}}{\text{One-Thousandth}}$ (.001) of an inch, is the practical basis for determining the diameters and thereby the area of all wires used as electric conductors. The diameters being given, the area is obtained by the well-known rule, "the area of a circle, in circular units, is equal to the square of its diameter"; hence the square of the diameter of a wire expressed in mils equals the area of its cross section.

$D^2=A$, which area is expressed in Circular Mils or CM, hence

$$D^2=CM.$$

WIRING FORMULA

Ohm's law is practically the basis for the various formulæ in general use for determining the proper size of wire to use to carry various currents. It is essential to know the amount of current expressed in amperes, the distance, and to decide upon the loss to allow in transmission; the best rule is as follows:

The cross section (CM) of the necessary wire is found by multiplying twice the distance one way (2D) by the amount of current expressed in amperes (C) and this by the resistance of one mil-foot (10.7) and dividing by the loss in transmission expressed in volts (v.)

$$\text{or, } CM=\frac{2D \times C \times 10.7}{v} \text{ or, } CM=\frac{D \times C \times 21.4}{v}$$

WIRING FORMULA

From Ohm's Law the proper size of wire that is necessary to carry a current any distance with a given loss in volts can readily be determined.

$$\frac{\text{Length of run in ft. x amperes x 21.5}}{\text{Volts lost.}}=\text{Circular Mils}$$

In the above Formula the number of feet must be measured one way, not both sides of the circuit; volts lost should be taken as the drop allowed in volts, and circular mils show the size of wire to use.

Example:—What size wire should be used on a 250-volt circuit where it is necessary to carry 150 amperes a distance of 300 feet to a center of distribution with a loss of 3 per cent under a full load?

$$\frac{300 \times 150 \times 21.5}{7.5}$$

=129,000 circular mils, or No. 00 B. & S. gauge which is the next size heavier.

In using this or any other formula to determine the size of copper to use, care should be taken to see that the size adopted is not smaller than allowed in the Underwriter's table of safe carrying capacities, which are fixed without considering the loss in line.

The general practice in balanced 3-wire direct-current systems with a central neutral wire is to figure the line loss on the same size as either of the others.

The above Wiring Formula is based upon one foot of copper wire, having a cross sectional area of one circular mil, with a resistance of approximately 10.75 ohms, so that the resistance of any copper wire—

$$\frac{\text{Length in feet x 10.75}}{\text{Circular Mils}}$$

Substituting this expression for R. in Ohm's Law:

$$E=\frac{\text{C x length in feet x 10.75}}{\text{Circular Mils}}$$

and circular mils=

$$\frac{\text{C x length in feet x 10.75}}{E}$$

In the Wiring Formula, however, the length in feet is considered the "run" one side of the circuit, and the term 10.75 is multiplied by 2.

CARRYING CAPACITIES OF INSULATED WIRES AND CABLES

The following table gives the allowable continuous current carrying capacities of copper wires and cables of 98 per cent conductivity, according to the standard adopted by the American Institute of Electrical Engineers.

ALLOWABLE CARRYING CAPACITIES OF WIRES

Gage No.	Diameter of Solid Wires in Mils	Area in Circular Mils	Rubber Insulation Amperes	Varnished Cambric Insulation Amperes	Other Insulation Amperes
18	40.3	1,624	3	--------	5
16	50.8	2,583	6	--------	10
14	64.1	4,107	15	18	20
12	80.8	6,530	20	25	25
10	101.9	10,380	25	30	30
8	128.5	16,510	35	40	50
6	162.0	26,250	50	60	70
5	181.9	33,100	55	65	80
4	204.3	41,740	70	85	90
3	229.4	52,630	80	95	100
2	257.6	66,370	90	110	125
1	289.3	83,690	100	120	150
0	325.	105,500	125	150	200
00	364.8	133,100	150	180	225
000	409.6	167,800	175	210	275
--------	----------	200,000	200	240	300
0000	460.	211,600	225	270	325
--------	----------	250,000	250	300	350
--------	----------	300,000	275	330	400
--------	----------	350,000	300	360	450
--------	----------	400,000	325	390	500
--------	----------	500,000	400	480	600
--------	----------	600,000	450	540	680
--------	----------	700,000	500	600	760
--------	----------	800,000	550	660	840
--------	----------	900,000	600	720	920
--------	----------	1,000,000	650	780	1,000
--------	----------	1,100,000	690	830	1,080
--------	----------	1,200,000	730	880	1,150
--------	----------	1,300,000	770	920	1,220
--------	----------	1,400,000	810	970	1,290
--------	----------	1,500,000	850	1,020	1,360
--------	----------	1,600,000	890	1,070	1,430
--------	----------	1,700,000	930	1,120	1,490
--------	----------	1,800,000	970	1,160	1,550
--------	----------	1,900,000	1,010	1,210	1,610
--------	----------	2,000,000	1,050	1,260	1,670

For aluminum wire the allowable carrying capacities shall be taken as 84 per cent of those given in the table for the respective sizes of copper wire with the same kind of covering.

Conductors of size numbers 18 and 16 shall be used only for flexible cords and for fixture wires.

Conductors may be placed in multiple only by permission of the authority enforcing this code.

Varnished cambric insulated wires smaller than number 6 shall be used only by permission of the authority enforcing this code.

CARRYING CAPACITY OF INSULATED COPPER CONDUCTORS

THREE CONDUCTOR CABLES

The following values for carrying capacity must not be assumed unless it is positively known that the conditions upon which they are based will not be exceeded in service.

B. & S. NO. AREA IN CIRCULAR MILS	XX Carrying Capacity in Amperes Direct Current Based Upon 30° C Rise and a Maximum of 3000 Volts Paper Insulation	K.V.A. which may be transmitted at three phase and the following voltages over **paper insulated lead covered** cables installed in a **four duct** line with 30° C rise in temperature based upon the assumption that all ducts carry loaded cables and upon a normal earth temperature of 20° C. For a 6 duct line these K.V.A. values would be reduced to approximately 88 per cent for an 8 duct line to 79 per cent for a 10 duct line to 71 per cent for a 12 duct line to 63 per cent and for a 16 duct line (4 wide and 4 high) to 60 per cent of the table values XXXX.																
		220 Volts	440 Volts	550 Volts	1100 Volts	2200 Volts	3300 Volts	4000 Volts	6000 Volts	6600 Volts	10000 Volts	11000 Volts	12000 Volts	13200 Volts	15000 Volts	20000 Volts	22000 Volts	25000 Volts
14	18	7	14	17	34	68	103	124	184	202	300	328	356	390	438	570	620	693
12	22	8	17	21	42	84	125	152	225	247	367	400	435	477	536	695	757	847
10	30	11	23	28	57	114	171	206	307	336	500	547	595	650	730	950	1035	1155
8	40	15	30	38	76	152	228	275	410	450	667	730	792	867	975	1265	1380	1540
6	55	21	42	52	104	209	314	378	562	616	917	1000	1090	1190	1340	1740	1895	2120
4	70	26	53	66	133	266	400	482	715	785	1170	1275	1385	1520	1710	2215	2410	2700
2	95	36	72	90	180	361	543	655	970	1065	1585	1730	1880	2060	2310	3000	3270	3650
1	110	42	84	105	209	418	628	755	1125	1230	1840	2050	2180	2390	2680	3480	3780	4240
0	130	49	99	123	247	495	740	895	1330	1460	2170	2370	2580	2820	3170	4120	4470	5000
00	150	57	114	143	285	570	855	1030	1535	1710	2500	2740	2970	3260	3660	4750	5170	5770
000	170	65	130	162	323	647	970	1170	1740	1940	2840	3100	3370	3690	4150	5375	5850	6550
0000	200	76	152	190	380	760	1140	1375	2040	2240	3340	3650	3960	4340	4870	6325	6900	7700
250 000	225	86	172	214	428	857	1285	1550	2300	2520	3750	4100	4450	4880	5470	7125	7750	8650
300 000	250	95	190	238	475	950	1430	1720	2560	2800	4170	4550	4950	5425	6100	7900	8600	9625
350 000	280	106	213	266	532	1065	1600	1925	2860	3140	4670	5100	5550	6070	6825	8850	9650	10800
400 000	310	118	236	295	590	1180	1770	2130	3170	3480	5170	5650	6150	6720	7550	9800	10700	11950
450 000	340	129	258	323	647	1295	1940	2340	3480	3810	5670	6200	6750	7370	8300	10750	11700	13100
500 000	360	137	274	342	685	1370	2050	2480	3680	4040	6000	6550	7130	7800	8770	11400	12400	13850
600 000	400	152	304	380	760	1520	2280	2760	4100	4500	6680	7300	7920	8680	9750	12650	13800	15400
700 000	470	179	358	447	895	1790	2680	3240	4800	5270	7820	8570	9300	10200	11450	14850	16200	18100

XX For four conductor cables these ampere values would be reduced by 12.5 percent.

XXXX For the higher voltage cables the kv-a values of the table have been reduced by one percent for each 2000 volts that the working pressure exceeds 3000 volts, that is by 11 percent for a 25 000 volt cable. For insulated aluminum conductors the safe carrying capacity (based upon 61 percent conductivity) is 79.3 percent of the above table values with the same kind of insulation. These kv-a values are based upon the current in columns headed by XX and XXX.

CARRYING CAPACITY OF INSULATED COPPER CONDUCTORS (Continued)

SINGLE CONDUCTOR CABLES

K.V.A. which may be transmitted at three phase and the following voltages over three **paper insulated lead covered** cables installed in a **four duct** line with 30° C rise in temperature based upon the assumption that all ducts carry loaded cables and upon a normal earth temperature of 20° C.

For a 6 duct line these K.V.A. values would be reduced to approximately 88 per cent for an 8 duct line to 79 per cent for a 10 duct line to 71 per cent; for a 12 duct line to 63 per cent and for a 16 duct line (4 wide and 4 high) to 60 per cent of the table values X X X X.

B. & S. NO AREA IN CIRCULAR MILS	Carrying Capacity In Amperes Direct Current: N. E. Code Int. Conductors: X Table A Rubber Insulation	X Table B Other Insulation	XXX Based Upon 30° C Rise & a Maximum of 3000 Volts Paper Insulation	220 Volts	440 Volts	550 Volts	1100 Volts	2200 Volts	3300 Volts	4000 Volts	6000 Volts	6600 Volts	10000 Volts	11000 Volts	12000 Volts	13200 Volts	15000 Volts	20000 Volts	22000 Volts	25000 Volts
14	15	20	24	9	18	23	46	92	137	165	245	270	400	437	475	520	585	758	826	925
12	20	25	30	11	23	28	57	114	171	206	306	337	500	547	595	650	732	948	1033	1155
10	25	30	40	15	30	38	76	152	228	275	408	450	667	730	792	868	975	1265	1378	1540
8	35	50	55	21	42	52	104	209	314	378	560	617	917	1010	1090	1195	1340	1740	1895	2120
7	..	..	..	..	..	..	...	...	...	...	...	...	....	....	....	....	....	....	....	....
6	50	70	75	28	57	71	142	284	428	515	765	842	1250	1270	1485	1630	1830	2370	2580	2890
5	55	80	..	..	..	..	...	...	...	...	...	....	....	....	....	....	....	....	....	....
4	70	90	95	36	72	90	181	362	540	653	970	1065	1585	1730	1880	2060	2320	3000	3270	3660
3	80	100	..	..	..	..	...	...	...	...	...	....	....	....	....	....	....	....	....	....
2	90	125	125	47	95	119	237	475	712	860	1275	1405	2085	2280	2480	2710	3050	3950	4300	4820
1	100	150	150	57	114	143	285	570	855	1030	1530	1685	2500	2715	2970	3260	3660	4740	5170	5780
0	125	200	170	65	130	162	323	647	970	1170	1740	1910	2830	3100	3370	3690	4150	5380	5850	6550
00	150	225	200	76	152	190	380	760	1140	1380	2040	2280	3330	3650	3960	4350	4880	6320	6880	7700
000	175	275	230	87	175	219	437	875	1310	1580	2350	2620	3840	4200	4550	5000	5600	7270	7920	8860
0000	225	325	270	103	205	256	512	1025	1540	1860	2760	3030	4500	4920	5350	5850	6580	8530	9300	10400
250 000	...	...	300	114	228	285	570	1140	1710	2060	3070	3370	5000	5470	5950	6500	7320	9500	10350	11550
300 000	275	400	340	129	259	324	647	1295	1940	2340	3470	3820	5670	6200	6730	7380	8300	10750	11700	13200
350 000	...	...	380	144	289	362	723	1445	2170	2620	3880	4270	6330	6920	7520	8250	9260	12000	13100	14650
400 000	325	500	410	156	312	390	780	1560	2340	2820	4180	4600	6850	7480	8120	8900	10000	12950	14150	15800
450 000	...	...	450	172	343	428	855	1710	2560	3100	4600	5050	7500	8200	8900	9770	10900	14200	15500	17350
500 000	400	600	480	183	365	456	912	1825	2740	3300	4900	5400	8000	8750	9500	10400	11700	15200	16550	18500

CARRYING CAPACITY OF INSULATED COPPER CONDUCTORS (Continued)

SINGLE CONDUCTOR CABLES

K.V.A. which may be transmitted at three phase and the following voltages over three **paper insulated lead covered** cables installed in a **four duct** line with 30° C rise in temperature based upon the assumption that all ducts carry loaded cables and upon a normal earth temperature of 20° C.

For a 6 duct line these K.V.A. values would be reduced to approximately 88 per cent for an 8 duct line to 79 per cent for a 10 duct line to 71 per cent; for a 12 duct line to 63 per cent and for a 16 duct **line** (4 wide and 4 high) to 60 per cent of the table values X X X X.

B. & S. NO AREA IN CIRCULAR MILS	Carrying Capacity In Amperes Direct Current: N. E. Code Int. Conductors: X Table A Rubber Insulation	X Table B Other Insulation	XXX Based Upon 30° C Rise & a Maximum of 3000 Volts Paper Insulation	220 Volts	440 Volts	550 Volts	1100 Volts	2200 Volts	3300 Volts	4000 Volts	6000 Volts	6600 Volts	10000 Volts	11000 Volts	12000 Volts	13200 Volts	15000 Volts	20000 Volts	22000 Volts	25000 Volts
600 000	450	680	550	209	418	522	1045	2090	3140	3790	5620	6180	9170	10000	10900	11950	13400	17400	18950	21200
700 000	500	760	610	232	464	580	1160	2320	3480	4200	6220	6850	10150	11100	12100	13250	14850	19300	21000	23500
800 000	550	840	670	255	510	638	1275	2550	3820	4600	6850	7520	11150	12200	13250	14550	16350	21200	23100	25800
900 000	600	920	720	274	548	685	1370	2740	4100	4950	7350	8100	12000	13150	14250	15650	17550	22700	24800	27700
1 000 000	650	1000	780	297	594	742	1480	2960	4450	5370	7950	8750	13000	14200	15450	16950	19000	24650	26800	30100
1 100 000	690	1080	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1 200 000	730	1150	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1 250 000	...	...	900	342	685	855	1710	3420	5130	6200	9200	10100	15000	16400	17800	19550	21900	28400	31000	34700
1 300 000	770	1220	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1 400 000	810	1290	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1 500 000	850	1360	1030	392	785	980	1960	3920	5870	7100	10500	11550	17200	18800	20400	22400	25100	32600	35500	39700
1 600 000	890	1430	....	...	...	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1 750 000	...	...	1130	430	860	1075	2150	4300	6450	7770	11550	12700	18800	20600	22400	24500	27500	35700	39000	43600
1 900 000	1010	1610	....	...	...	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
2 000 000	1050	1670	1260	480	960	1200	2400	4800	7200	8670	12850	14150	21000	23000	25000	27300	30700	39800	43300	48600

X For purposes of comparison these values are given for interior conductors.

XX For four conductor cables these ampere values would be reduced by 12.5 percent.

XXX For solid conductors these ampere ratings would be reduced by seven percent. For two conductor cables made up either round or flat, they would be reduced by 15 per cent. For two conductor concentric cables they would be reduced by 25 percent. They will also be reduced in the case of the larger conductors when used on alternating-current circuits on account of skin effect, unless special cables having non-conducting cores are used. These special cables should be used for 700 000 circ. mils and larger for 60 cycle and 1 000 000 circ. mils and larger for 25 cycle service.

XXXX For the higher voltage cables the kv-a values of the table have been reduced by one per cent for each 2000 volts that the working pressure exceeds 3000 volts, that is by 11 percent for a 25 000 volt cable. For insulated aluminum conductors the safe carrying capacity (based upon 61 percent conductivity) is 79.3 percent of the above table values with the same kind of insulation. These kv-a values are based upon the current in columns headed by XX and XXX.

CABLE AND CONDUIT SIZES—Continued

COND'R. SIZE	VC Lead Covered Cable 600 & 1250 Volt SC-AC				VC Lead Covered Cable 3000 Volt SC-AC				VC Lead Covered Cable 5000 Volt SC-AC			
	VC Wall	Lead Wall	Lead OD	Conduit Size	VC Wall	Lead Wall	Lead OD	Conduit Size	VC Wall	Lead Wall	Lead OD	Conduit Size
14	3/64	3/64	.27	3/4	4/32	3/64	.42	1	----	----	--------	------
12	3/64	3/64	.28	3/4	4/32	3/64	.44	1	----	----	--------	------
10	3/64	3/64	.30	3/4	4/32	3/64	.46	1	6/32	1/16	.62	1
8	3/64	3/64	.33	3/4	4/32	1/16	.52	1	6/32	1/16	.64	1
6	1/16	3/64	.42	1	4/32	1/16	.57	1	6/32	1/16	.70	1
4	1/16	3/64	.46	1	4/32	1/16	.62	1	6/32	1/16	.75	1
2	1/16	1/16	.56	1	4/32	1/16	.68	1¼	6/32	5/64	.84	1¼
1	5/64	1/16	.63	1	4/32	1/16	.72	1¼	6/32	5/64	.88	1¼
1/0	5/64	1/16	.67	1	4/32	1/16	.76	1¼	6/32	5/64	.92	1¼
2/0	5/64	1/16	.71	1	4/32	5/64	.84	1¼	6/32	5/64	.96	1¼
3/0	5/64	1/16	.76	1¼	4/32	5/64	.89	1¼	6/32	5/64	1.02	1½
4/0	5/64	5/64	.85	1¼	4/32	5/64	.95	1¼	6/32	5/64	1.07	1½
250,000	3/32	5/64	.93	1¼	4/32	5/64	1.00	1½	6/32	3/32	1.15	1½
300,000	3/32	5/64	.99	1½	4/32	5/64	1.05	1½	6/32	3/32	1.21	2
350,000	3/32	5/64	1.04	1½	4/32	5/64	1.10	1½	6/32	3/32	1.26	2
400,000	3/32	5/64	1.09	1½	4/32	3/32	1.18	1½	6/32	3/32	1.31	2
500,000	3/32	3/32	1.20	1½	4/32	3/32	1.27	2	6/32	3/32	1.39	2
600,000	7/64	3/32	1.31	2	4/32	3/32	1.35	2	6/32	3/32	1.47	2½
650,000	7/64	3/32	1.36	2	4/32	3/32	1.39	2	6/32	3/32	1.51	2½
700,000	7/64	3/32	1.39	2	4/32	3/32	1.42	2	6/32	3/32	1.55	2½
750,000	7/64	3/32	1.42	2	4/32	3/32	1.45	2	6/32	3/32	1.58	2½
800,000	7/64	3/32	1.45	2	4/32	3/32	1.48	2½	6/32	7/64	1.64	2½
900,000	7/64	3/32	1.53	2½	4/32	3/32	1.56	2½	6/32	7/64	1.72	2½
1,000,000	7/64	3/32	1.58	2½	4/32	7/64	1.64	2½	6/32	7/64	1.77	2½
1,250,000	4/32	7/64	1.82	2½	----	----	--------	------	6/32	7/64	1.92	3
1,500,000	4/32	7/64	1.90	3	----	----	--------	------	6/32	7/64	2.02	3
1,750,000	4/32	7/64	2.04	3	----	----	--------	------	6/32	1/8	2.20	3½
2,000,000	4/32	7/64	2.11	3	----	----	--------	------	6/32	1/8	2.30	3½

Braided cable take same dimensions.

CABLE AND CONDUIT SIZES—Continued

COND'R.	VC Lead Covered Cable 8500 Volt SC-AC				VC Lead Covered Cable 11500 Volt SC-AC				VC Lead Covered Cable 13500 Volt SC-AC			
SIZE	VC Wall	Lead Wall	Lead OD	Conduit Size	VC Wall	Lead Wall	Lead OD	Cond. duit Size	VC Wall	Lead Wall	Lead OD	Conduit Size
14	----	----	--------	------	----	----	--------	------	----	----	--------	------
12	----	----	--------	------	----	----	--------	------	----	----	--------	------
10	----	----	--------	------	----	----	--------	------	----	----	--------	------
8	8/32	1/16	.77	1¼	----	----	--------	------	----	----	--------	------
6	8/32	5/64	.85	1¼	----	----	--------	------	----	----	--------	------
4	8/32	5/64	.90	1¼	10/32	5/64	1.03	1½	----	----	--------	------
2	8/32	5/64	.96	1½	10/32	5/64	1.10	1½	12/32	3/32	1.24	2
1	8/32	5/64	1.00	1½	10/32	5/64	1.16	1½	12/32	3/32	1.28	2
1/0	8/32	5/64	1.04	1½	10/32	3/32	1.20	1½	12/32	3/32	1.33	2
2/0	8/32	5/64	1.09	1½	10/32	3/32	1.25	2	12/32	3/32	1.37	2
3/0	8/32	3/32	1.17	1½	10/32	3/32	1.30	2	12/32	3/32	1.42	2
4/0	8/32	3/32	1.23	2	10/32	3/32	1.36	2	12/32	3/32	1.48	2
250,000	8/32	3/32	1.28	2	10/32	3/32	1.40	2	12/32	3/32	1.53	2½
300,000	8/32	3/32	1.34	2	10/32	3/32	1.46	2	12/32	3/32	1.59	2½
350,000	8/32	3/32	1.38	2	10/32	3/32	1.51	2½	12/32	3/32	1.63	2½
400,000	8/32	3/32	1.43	2	10/32	3/32	1.56	2½	12/32	7/64	1.71	2½
500,000	8/32	3/32	1.52	2½	10/32	7/64	1.67	2½	12/32	7/64	1.80	2½
600,000	8/32	7/64	1.63	2½	10/32	7/64	1.75	2½	12/32	7/64	1.88	3
650,000	8/32	7/64	1.67	2½	10/32	7/64	1.79	2½	12/32	7/64	1.92	3
700,000	8/32	7/64	1.70	2½	10/32	7/64	1.83	2½	12/32	7/64	1.95	3
750,000	8/32	7/64	1.73	2½	10/32	7/64	1.86	2½	12/32	7/64	1.98	3
800,000	8/32	7/64	1.76	2½	10/32	7/64	1.89	3	12/32	7/64	2.01	3
900,000	8/32	7/64	1.84	3	10/32	7/64	1.97	3	12/32	7/64	2.09	3
1,000,000	8/32	7/64	1.89	3	10/32	7/64	2.02	3	12/32	1/8	2.17	3
1,250,000	8/32	7/64	2.05	3	10/32	1/8	2.21	3	12/32	1/8	2.36	3½
1,500,000	8/32	1/8	2.18	3	10/32	1/8	2.33	3½	12/32	1/8	2.46	3½
1,750,000	8/32	1/8	2.55	3½	10/32	1/8	2.48	3½	12/32	1/8	2.60	3½
2,000,000	8/32	1/8	2.43	3½	10/32	1/8	2.55	3½	12/32	1/8	2.68	3½

Braided cable take same dimensions.

CABLE AND CONDUIT SIZES—Continued

SIZE	VC Lead Covered Cable 600 Volt 3C-AC				VC Lead Covered Cable 3000 Volt 3C-AC				VC Lead Covered Cable 5000 Volt 3C-AC			
	VC Wall	Lead Wall	Lead OD	Conduit Size	VC Wall	Lead Wall	Lead OD	Conduit Size	VC Wall	Lead Wall	Lead OD	Conduit Size
*14	3/64	3/64	.47	¾	1/16	1/16	.68	1	----	----	--------	------
12	3/64	3/64	.51	1	1/16	1/16	.72	1	----	----	--------	------
10	3/64	1/16	.59	1	1/16	1/16	.76	1	----	----	--------	------
8	3/64	1/16	.64	1¼	1/16	5/64	.85	1¼	3/32	5/64	1.05	1½
6	3/64	1/16	.78	1¼	1/16	5/64	.97	1¼	3/32	3/32	1.20	1½
4	3/64	5/64	.91	1¼	1/16	5/64	1.07	1½	3/32	3/32	1.31	2
2	3/64	5/64	1.04	1½	1/16	3/32	1.24	2	3/32	3/32	1.43	2
1	1/16	3/32	1.23	2	1/16	3/32	1.32	2	3/32	3/32	1.52	2½
1/0	1/16	3/32	1.32	2	1/16	3/32	1.41	2	3/32	7/64	1.64	2½
2/0	1/16	3/32	1.41	2	1/16	3/32	1.51	2½	3/32	7/64	1.74	2½
3/0	1/16	3/32	1.53	2½	1/16	7/64	1.65	2½	3/32	7/64	1.85	3
4/0	1/16	7/64	1.75	2½	1/16	7/64	1.84	2½	3/32	7/64	1.97	3
250,000	5/64	7/64	1.88	2½	5/64	7/64	1.94	3	3/32	7/64	2.07	3
300,000	5/64	7/64	2.01	3	5/64	7/64	2.07	3	3/32	1/8	2.23	3½
350,000	5/64	7/64	2.10	3	5/64	7/64	2.17	3	3/32	1/8	2.35	3½
400,000	5/64	1/8	2.24	3	5/64	1/8	2.32	3½	3/32	1/8	2.44	3½
500,000	5/64	1/8	2.44	3½	5/64	1/8	2.50	3½	3/32	1/8	2.63	4
600,000	3/32	1/8	2.68	4	3/32	1/8	2.74	4	3/32	1/8	2.87	4
700,000	3/32	1/8	2.84	4	3/32	1/8	2.90	4	3/32	9/64	3.06	4½
800,000	3/32	1/8	2.97	4½	3/32	9/64	3.07	4½	3/32	----	--------	------

NOTE:—Braided cable 3C-VC or paper take same size conduit. Outer band of insulation, thickness listed under "VC" wall.

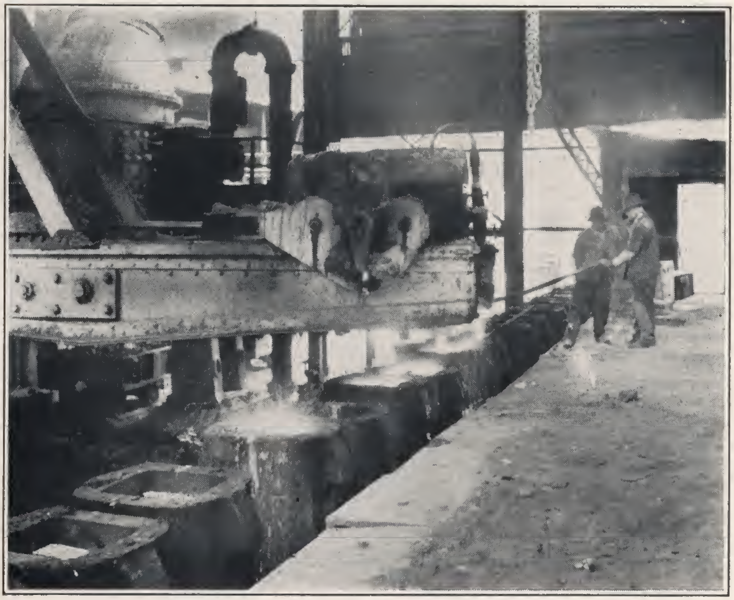
CABLE AND CONDUIT SIZES—Continued

SIZE	VC Lead Covered Cable 8500 Volt 3C-AC				VC Lead Covered Cable 11500 Volt 3C-AC				VC Lead Covered Cable 13500 Volt 3C-AC			
	VC Wall	Lead Wall	Lead OD	Conduit Size	VC Wall	Lead Wall	Lead OD	Conduit Size	VC Wall	Lead Wall	Lead OD	Conduit Size
6	4/32	3/32	1.40	2	----	----	--------	------	----	----	--------	------
4	4/32	3/32	1.50	2	5/32	7/64	1.73	2½	----	----	--------	------
2	4/32	7/64	1.66	2½	5/32	7/64	1.86	3	6/32	7/64	2.05	2½
1	4/32	7/64	1.75	2½	5/32	7/64	1.94	3	6/32	1/8	2.17	3
1/0	4/32	7/64	1.83	3	5/32	7/64	2.03	3	6/32	1/8	2.27	3½
2/0	4/32	7/64	1.93	3	5/32	1/8	2.16	3	6/32	1/8	2.37	3½
3/0	4/32	7/64	2.04	3	5/32	1/8	2.29	3½	6/32	1/8	2.48	3½
4/0	4/32	1/8	2.20	3	5/32	1/8	2.41	3½	6/32	1/8	2.61	4
250,000	4/32	1/8	2.31	3½	5/32	1/8	2.51	3½	6/32	1/8	2.71	4
300,000	4/32	1/8	2.44	3½	5/32	1/8	2.64	4	6/32	1/8	2.84	4
350,000	4/32	1/8	2.54	3½	5/32	1/8	2.74	4	6/32	1/8	2.94	4½
400,000	4/32	1/8	2.64	4	5/32	1/8	2.84	4	6/32	9/64	3.07	4½
500,000	4/32	1/8	2.83	4	5/32	9/64	3.06	4½	6/32	9/64	3.25	4½
600,000	4/32	1/8	3.00	4½	5/32	9/64	3.23	4½	----	----	--------	------
700,000	4/32	9/64	3.19	4½	----	----	--------	------	----	----	--------	------

NOTE:—Braided cable 3C-VC or paper take same size conduit. Outer band of insulation thickness size of "VC wall."

VOLTS LOST PER 1,000 FEET PER AMPERE

Size Circular Mils	Volts Lost	Size Circular Mils	Volts Lost
2,000,000	0.00535	0000	0.05053
1,750,000	0.00611	000	0.06372
1,500,000	0.00713	00	0.08035
1,250,000	0.00856	0	0.10126
1,000,000	0.01070	1	0.12776
950,000	0.01126	2	0.16109
900,000	0.01189	3	0.20315
850,000	0.01259	4	0.25615
800,000	0.01337	5	0.32302
750,000	0.01427	6	0.40732
700,000	0.01529	7	0.51367
650,000	0.01646	8	0.64767
600,000	0.01783	9	0.81659
550,000	0.01945	10	1.0300
500,000	0.02140	12	1.6375
450,000	0.02378	14	2.6685
400,000	0.02675	16	4.1397
350,000	0.03057	18	6.5828
300,000	0.03567	19	8.5376
250,000	0.04280	20	10.467



Teeming a Bessemer Heat. Casting into Ingot Molds.

WIRE AND SHEET METAL GAUGES

In Approximate Decimals of an Inch
(Adopted by the Association of American Steel Manufacturers, Dec. 10, 1908)

Gauge Numbers	United States	American or Brown & Sharpe	Washburn & Moen, Am Steel & Wire Co. Roebling	Trenton Iron Co.	Birmingham or Stubs' Iron Wire	Stubs' Steel Wire	British Imperial	Gauges Number
7–0	.500	....	....	....	....	....	.500	7–0
6–0	.469	....	.460	....	....	....	.464	6–0
5–0	.438	....	.430	.450	....	....	.432	5–0
4–0	.406	.460	.394	.400	.454	....	.400	4–0
000	.375	.410	.363	.360	.425	....	.372	000
00	.344	.365	.331	.330	.380	....	.348	00
0	.313	.325	.307	.305	.340	....	.324	0
1	.281	.289	.283	.285	.300	.227	.300	1
2	.266	.258	.263	.265	.284	.219	.276	2
3	.250	.229	.244	.245	.259	.212	.252	3
4	.234	.204	.225	.225	.238	.207	.232	4
5	.219	.182	.207	.205	.220	.204	.212	5
6	.203	.162	.192	.190	.203	.201	.192	6
7	.188	.144	.177	.175	.180	.199	.176	7
8	.172	.128	.162	.160	.165	.197	.160	8
9	.156	.114	.148	.145	.148	.194	.144	9
10	.141	.102	.135	.130	.134	.191	.128	10
11	.125	.0907	.121	.118	.120	.188	.116	11
12	.109	.0808	.106	.105	.109	.185	.104	12
13	.0938	.072	.0915	.0925	.095	.182	.092	13
14	.0781	.0641	.080	.0806	.083	.180	.080	14
15	.0703	.0571	.072	.070	.072	.178	.072	15
16	.0625	.0508	.0625	.061	.065	.175	.064	16
17	.0563	.0453	.054	.0525	.058	.172	.056	17
18	.050	.0403	.0475	.045	.049	.168	.048	18
19	.0438	.0359	.041	.040	.042	.164	.040	19
20	.0375	.032	.0348	.035	.035	.161	.036	20
21	.0344	.0285	.0318	.031	.032	.157	.032	21
22	.0313	.0253	.0286	.028	.028	.155	.028	22
23	.0281	.0226	.0258	.025	.025	.153	.024	23
24	.025	.0201	.023	.0225	.022	.151	.022	24
25	.0219	.0179	.0204	.020	.020	.148	.020	25
26	.0188	.0159	.0181	.018	.018	.146	.018	26
27	.0172	.0142	.0173	.017	.016	.143	.0164	27
28	.0156	.0126	.0162	.016	.014	.139	.0149	28
29	.0141	.0113	.015	.015	.013	.134	.0136	29
30	.0125	.010	.014	.014	.012	.127	.0124	30
31	.0109	.0089	.0132	.013	.010	.120	.0116	31
32	.0102	.008	.0128	.012	.009	.115	.0108	32
33	.0094	.0071	.0118	.011	.008	.112	.010	33
34	.0086	.0063	.0104	.010	.007	.110	.0092	34
35	.0078	.0056	.0095	.0095	.005	.108	.0084	35
36	.007	.005	.009	.009	.004	.106	.0076	36
37	.0066	.0045	.0085	.0085	....	.103	.0068	37
38	.0063	.004	.008	.008	....	.101	.006	38
39	....	.0035	.0075	.0075	....	.099	.0052	39
40	....	.0031	.007	.007	....	.097	.0048	40

DECIMAL EQUIVALENT OF AN INCH

1/32	1/64	Decimal	Fraction	1/32	1/64	Decimal	Fraction
	1	.015625			33	.515625	
1	2	.03125		17	34	.53125	
	3	.046875			35	.546875	
2	4	.0625	1/16	18	36	.5625	9/16
	5	.078125			37	.578125	
3	6	.09375		19	38	.59375	
	7	.109375			39	.609375	
4	8	.125	1/8	20	40	.625	5/8
	9	.140625			41	.640625	
5	10	.15625		21	42	.65625	
	11	.171875			43	.671875	
6	12	.1875	3/16	22	44	.6875	11/16
	13	.203125			45	.703125	
7	14	.21875		23	46	.71875	
	15	.234375			47	.734375	
8	16	.25	1/4	24	48	.75	3/4
	17	.265625			49	.765625	
9	18	.28125		25	50	.78125	
	19	.296875			51	.796875	
10	20	.3125	5/16	26	52	.8125	13/16
	21	.328125			53	.828125	
11	22	.34375		27	54	.84375	
	23	.359375			55	.859375	
12	24	.375	3/8	28	56	.875	7/8
	25	.390625			57	.890625	
13	26	.40625		29	58	.90625	
	27	.421875			59	.921875	
14	28	.4375	7/16	30	60	.9375	15/16
	29	.453125			61	.953125	
15	30	.46875		31	62	.96875	
	31	.484375			63	.984375	
16	32	.5	1/2	32	64	1.	1

Decimal Equivalents of an Inch

For Birmingham Wire Gauge

B W. G.	Decimal	B. W. G.	Decimal	B. W. G.	Decimal
4–0	.454	11	.120	25	.020
000	.425	12	.109	26	.018
00	.380	13	.095	27	.016
0	.340	14	.083	28	.014
1	.300	15	.072	29	.013
2	.284	16	.065	30	.012
3	.259	17	.058	31	.010
4	.238	18	.049	32	.009
5	.220	19	.042	33	.008
6	.203	20	.035	34	.007
7	.180	21	.032	35	.005
8	.165	22	.028	36	.004
9	.148	23	.025		
10	.134	24	.022		

MEASURES AND WEIGHTS

Linear Measure

12 inches=1 foot 3 feet=1 yard 5½ yards=1 rod
40 rods=1 furlong 8 furlongs=1 mile

Equivalent Values

Inches	Feet	Yards	Rods	Furl'gs	Miles
36=	3=	1			
198=	16.5=	5.5=	1		
7,920=	660=	220=	40 =	1	
63,360=	5,280=	1,760=	320 =	8 =	1

SQUARE MEASURE

144 square inches=1 square foot
9 square feet=1 square yard
30¼ square yards=1 square rod
160 square rods=1 acre
640 acres=1 square mile

Equivalent Values

Square mile	Acres	Square rods	Square yards
1 =	640 =	102,400 =	3,097,600

Square mile	Square feet	Square inches
1 =	27,878,400 =	4,014,489,600

Cubic Measure

1,728 cubic inches=1 cubic foot
27 cubic feet=1 cubic yard
128 cubic feet=1 cord
24¾ cubic feet=1 perch
1 cubic yard=27 cubic feet=46,656 cubic inches

Weight—Avoirdupois

437½ grains=1 ounce 16 ounces=1 pound
100 pounds=1 hundredweight
2,000 pounds=1 ton 2,240 pounds=1 long ton
1 ton=20 cwt.=2,000 pounds=32,000 ounces=
14,000,000 grains
1 pound av.=7,000 grains

MEASURES AND WEIGHTS

Measure of Angles or Arcs

60 seconds=1 minute
60 minutes=1 degree
90 degrees=1 right angle or quadrant
360 degrees=1 circle
1 circle=360°=21,600 =1,296,000″
1 minute of arc on the earth's surface=1 nautical mile=1.17 times a land mile or 6,080 feet

Mariners' Measure

6 feet=1 fathom
5,280 feet=1 stat. mile
120 fathoms=1 cable length
6,085 feet=1 nautical mile
7½ cable lengths=1 mile

Miscellaneous

3 inches=1 palm
4 inches=1 hand
9 inches=1 span
12 articles=1 dozen
12 dozen=1 gross
12 gross=1 great gross
2 articles=1 pair
18 inches=1 cubit
21.8 inches=1 bible cubit
2½ feet=1 military pace
1 league=3 miles
20 articles=1 score
24 sheets=1 quire
20 quires=1 ream

Weight—Troy

24 grains=1 pennyweight
20 pennyweights=1 ounce
12 ounces=1 pound
1 pound=12ounces=240 pennyweights=5,760 grains

Dry Measure

2 pints=1 quart
8 quarts=1 peck
4 pecks=1 bushel
1 bushel=4 pecks 4 pecks=32 quarts=64 pints
U. S. Bushel=2,150.42 cu. in.
British=2,218.19 cu. in.

TABLE OF MULTIPLES

Diameter of a circle×3.1416=Circumference.

Radius of a circle×6.283185=Circumference.

Square of the radius of a circle×3.1416=Area.

Square of the diameter of a circle×0.7854=Area.

Square of the circumference of a circle×0.07958 =Area.

Half the circumference of a circle×by half its diameter= Area.

Circumference of a circle×0.159155=Radius.

Square root of the area of a circle×0.56419= Radius.

Circumference of a circle×0.31831=Diameter.

Square root of the area of a circle×1.12838= Diameter.

Diameter of a circle×0.86=Side of an inscribed equilateral triangle.

Diameter of a circle×0.7071=Side of an inscribed square.

Circumference of a circle×0.225=Side of an inscribed square.

Circumference of a circle×0.282=Side of an equal square.

Diameter of a circle×0.8862=Side of an equal square.

Base of a triangle×by one-half the altitude=Area.

Multiplying both diameter and .7854 together= Area of an ellipse.

Surface of a sphere×by one-sixth of its diameter =Solidity.

Circumference of a sphere×by its diam.=Surface.

Square of the diam. of a sphere×3.1416=Surface.

Square of the circumference of a sphere×0.3183 =Surface.

Cube of the diam. of a sphere×0.5236=Solidity.

Cube of the circumference of a sphere×0.016887 =Solidity.

Radius of a sphere×1.1547=Side of an inscribed cube.

Square root of (one-third of the square of) the diam. of a sphere=Side of an inscribed cube.

Area of its base×one-third of its altitude=Solidity of a cone or pyramid, whether round, square or triangular.

Area of one of its sides×6=Surface of a cube.

Altitude of trapezoid×one-half the sum of its parallel sides=Area.

EQUIVALENT VALUE IN DIFFERENT UNITS

1 H. P.=

746 watts
.746 K.W.
33,000 ft.-lbs. per minute
550 ft.-lbs. per second
2,545 heat-units per hour
42.4 heat-units per minute
.707 heat-unit per second
.175 lb. carbon oxidized per hour
2.64 lbs. water evaporated per hour from and at 212° F.

1 H. P. Hour=

746 K. W. hours
1,980,000 ft.-lbs.
2,545 heat-units
273,740 k.g.m.
.175 lb. carbon oxidized with perfect efficiency
2.64 lbs. water evaporated from and at 212°F.
17.0 lbs. water raised from 62° to 212° F.

1 Kilowatt=

1,000 watts
1.34 H. P.
2,654,200 ft.-lbs. per hour
44,240 ft.-lbs. per minute
737.3 ft-lbs. per second
3,412 heat-units per hour
56.9 heat-units per minute
.948 heat-unit per second
.2275 lb. carbon oxidized per hour
3.53 lbs. water evaporated per hour from and at 212° F.

EQUIVALENT VALUE IN DIFFERENT UNITS

1 Watt per Sq. In=

8.19 heat-units per sq. ft. per minute
6,371 ft.-lbs. per sq. ft. per minute
.193 H. P. per sq. ft.

1 Kilogram Meter=

7.233 ft.-lbs.
.00000365 H.P. hour
.00000272 K. W. hour
.0093 heat-unit

1 Lb. Water Evaporated from and at 212° F.=

.283 K. W. hour
.379 H. P. hour
965.7 heat-units
103,900 k. g. m.
1,019,000 joules
751,300 ft.-lbs.
.0664 lb. of carbon oxidized

1 Heat-unit=

1,055 watt seconds
778 ft.-lbs.
107.6 kilogram meters
.000293 K. W. hour
.000393 H.P. hour
.0000688 lb. carbon oxidized
1001036 lb. water evaporated from and at 212° F.

1 Heat-unit per Sq. Ft. per Min.=

.122 watt per sq. in.
.0176 K. W. per sq. ft.
.0236 H.P. per sq. ft.

1 Watt=

1 joule per second
.00134 H. P.
3,412 heat-units per hour
.7373 ft.-lbs. per second
.0035 lb. water evaporated per hour
44.24 ft.-lbs. per minute

EQUIVALENT VALUE IN DIFFERENT UNITS

1 K. W. Hour=

1,000 watt hours
1.34 H.P. hours
2,645,200 ft.-lbs.
3,600,000 joules
3,412 heat-units
367,000 kilogram meters
.235 lb. carbon oxidized with perfect efficiency
3.53 lbs. water evaporated from and at 212°F.
22.75 lbs. of water raised from 62° to 212° F.

1 Joule=

1 watt second
.000000278 K. W. hour
.102 k. g. m.
.0009477 heat-units
.7373 ft-lb.

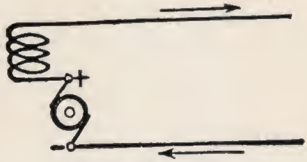
1 Ft.-lb.=

1.356 joules
.1383 k. g. m.
.000000377 K. W. hour
.001285 heat-unit
.0000005 H. P. hour

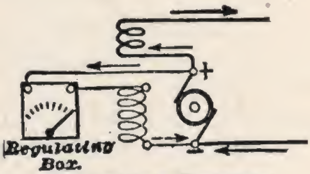
1 Lb. Carbon Oxidized with Perfect Efficiency=

14,544 heat-units
1.11 lbs. anthracite coal oxidized
2.5 lbs. dry wood oxidized
21 cu. ft illuminating gas
4.26 K. W. hours
5.71 H. P. hours
1,315,000 ft.-lbs.
15 lbs. of water evaporated from and at 212° F.

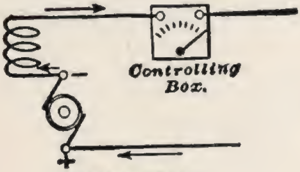
CONNECTIONS AND DATA ON D. C. GENERATORS AND MOTORS



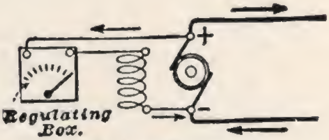
Series Dynamo



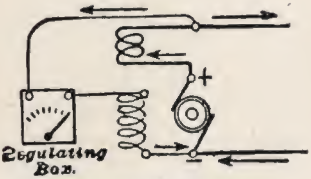
Compound Dynamo Short Shunt



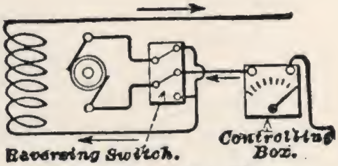
Series Motor



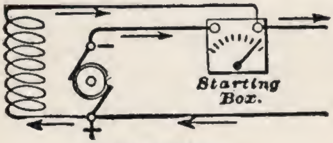
Shunt Dynamo



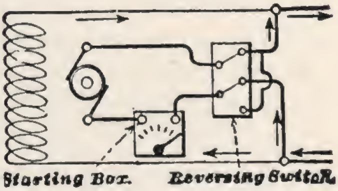
Compound Dynamo Long Shunt



Series Reversing Motor



Shunt Motor



Shunt Reversing Motor

The various types of direct current motors and generators are known relatively by the field windings, as series, shunt, compound and interpole. They are generally self-exciting but can be separately excited, in which case they are usually supplied with current from an outside source, such as a storage battery or another generator.

Series.—The field flux increases as the load current increases. In a series wound machine the field winding is in series with the armature. The speed of a series motor varies with the load. Its torque also increases with the increase of load and decreases with speed. The armature is at the highest speed at no load, and minimum speed at full load. Series motors are mostly used for driving exhaust fans, traction work, etc.

Shunt.—The field flux is practically constant at all loads .In a shunt wound machine a small portion of the current is shunted through the field winding. Shunt wound motors run at almost constant speed, with constant E. M. F. even though the load varies. Shunt wound generators are used for storage batteries, or any duty which requires a variation of E. M. F. Shunt wound motors are most suited for general work such as driving counter shafts, and constant speed machinery.

Compound.—The field flux increases slightly with the load current. In a compound wound machine the field has two sets of windings, a shunt winding and a series winding. The shunt winding furnishes the initial field strength, while the series winding furnishes a varying field strength, increasing or decreasing with the load. This automatic variation of field excitation maintains a constant voltage if from a generator, and an automatic speed control if used as a motor on constantly varying loads requiring automatic torque variation. Mostly used for elevator service.

Interpole.—The interpole motor or generator is sometimes known as "commutating pole type," because of its having an extra set of poles for the purpose of producing sparkless operation under extreme conditions of service. The field windings of the interpole machine are made series, shunt or compound. Highly recommended for all classes of service in preference to other types.

Alternating Current Generators are built in two types, known respectively as revolving field and revolving armature. The common names of the two sets of windings are rotor and stator. The revolving field type machine is the most commonly used type, because of the field current having only to pass through the brushes and collector rings and the high tension wires are all stationary. Alternating Current Generators are separately excited. That is, the field current is supplied from an auxiliary D. C. generator, known as an exciter. The current supplied from an A. C. Generator alternates in direction at regular intervals, and from this characteristic is derived the terms "frequency" or "cycles," which always has a numerical value which defines the period of the alternations. The most generally adopted systems operate at either 60 cycles, 7200 alternations, or 25 cycles, 3000 alternations, while there are some Central Stations which supply either 40 cycle, 50 cycle, or 133 cycle current. Alternating current is generated single, two or three phase, two and three phase systems being the most generally used, because of their being better adapted for the operation of large motors.

Alternating Current Motors are constructed single, two and three phase, and of many different types, and for all frequencies and synchronous speeds.

Single-phase Motors.—Single-phase motors are built in several different types, viz.: Repulsion, Repulsion Induction, and Induction Types, and are for constant or variable speed service. The Repulsion Induction Type is the most generally used of all single-phase motors and furnished for constant and variable speed.

Polyphase Induction Motors.—Polyphase Induction Motors are built in two types viz.: Squirrel Cage and Slip-Ring or Wire Wound Rotor Types. The Squirrel Cage Rotor Type motor has a nearly constant speed (starting torque high), and is the type most generally used for driving machinery. The Slip-ring motor is adapted for speed variation ranging from 50% to 100% and is also used for constant speed service. Both Squirrel Cage and Slip-ring type motors can be supplied for any frequency or voltage and for different speeds.

Starting Torque.—The starting torque of a constant speed motor is twice full load torque on full voltage. In general, the torque varies as the square of the applied voltage. The reason for using a reduced E. M. F. at starting is to reduce the sudden shock which may throw off belts or cause mechanical injury, and to reduce the starting current. When 50% voltage is applied to the motor, one-fourth full load torque is given.

Synchronous Motors are principally used for power factor correction and are also sometimes called "Synchronous Condensers," because they can be operated at a leading current to raise the power factor of an A. C. system. Synchronous motors for driving power are equipped with an extra starting winding, which will give from 30% to 50% full load torque, and will operate at a constant or synchronous speed with no slip. It is advisable to have one or more synchronous motors on all A. C. systems.

Starting of Synchronous Motors.—The starting of synchronous motors differs from the starting of induction motors, due to the fact that they have a field which is supplied from an auxiliary, known as an exciter. Before starting the motor, first see that the field discharge switch is open from the field of the motor, but the motor field must be short circuited through the field discharge resistance. To stop the motor, first turn the rheostat back to the zero power factor position, then open the field switch and throw off the compensator, the switches and rheostat being in position for next starting. If a synchronous motor which has sufficient starting torque to meet the load conditions should fail to start when the current is thrown into the stator windings, it is probably due to the "standing" relation of the field to the stator windings, because of there being an equal number of stator to rotor coils, and should they both be in a central position to each other, the rotor will not have any starting torque. To remedy this move the rotor a slight distance in either direction, and the motor will then start.

The relation of the horsepower (hp.), the volts (E), the amperes (I) and the efficiency in per cent (e) of the electric motor is expressed by the formula

$$\text{hp.} = \frac{EIe}{746}$$

This formula contains four quantities indicated by letters; if any three are known or can be assumed, the other one can be found. Efficiencies of industrial motors can be assumed at from 80% to 90%, depending upon the size.

For example, to determine the current required by a 10 hp., 220-volt motor of which the efficiency is unknown, assume 85% as an approximate value and apply the formula:

$$10 = \frac{220 \times I \times .85}{746}$$

$$\text{Therefore } I = \frac{10 \times 746}{220 \times .8} = 40 \text{ Approx.}$$

A rough approximation in determining the current required by direct-current motors is as follows:

8 amperes per hp. for 110–115-volt motors.

4 amperes per hp. for 220–230-volt motors.

1¾ amperes per hp. for 500-volt motors.

Horsepower.—Is a measure of the time rate of doing work and is defined as the equivalent of raising 33,000 pounds one foot in one minute. 1 hp. is equivalent to 746 watts.

Torque.—Is the pull or turning moment required in applying power by rotation and varies inversely as the radius at which the power is applied. The torque T is expressed in pounds at one foot radius, sometimes called pound-feet.

Full Load Torque.—Is the turning moment required to develop full rated output of a motor of given horsepower at a given speed.

The torque T of any motor at any output expressed in pounds at one foot radius can be found by means of the following formula:

$$T = \frac{5250 \times \text{hp.}}{\text{rpm.}}$$

Conversely if the torque in pounds at one foot radius is known, the horsepower at any given speed can be determined from the formula:

$$\text{H.P.} = \frac{\text{T} \times \text{RPM.}}{5250}$$

Starting Torque.—Is the turning moment a motor will develop in starting when impressed with a given starting voltage. Starting torque is usually expressed in terms of full load torque, as 2 times full load torque, etc.

Pullout Torque.—Or maximum running torque, is the maximum turning moment a motor will develop under running conditions. The P.O. torque of a wound rotor induction motor may be 80% of the maximum starting torque, while the P.O. torque of a squirrel cage induction motor will exceed the maximum starting torque, in some cases by as much as 100%. P.O. torque is usually expressed in terms of full load torque.

Efficiency.—Is the ratio of the useful "output" of a machine to its total "input."

Apparent Power.—In an alternating-current circuit is the product of the readings of the voltmeter and ammeter and is ordinarily expressed as kv-a. This value may be greater than the reading at the same time on the wattmeter.

True power in an alternating current circuit is the average value of the products of the coincident instantaneous values of the current and voltages for a complete cycle as indicated by the readings of a wattmeter and is ordinarily expressed in kw.

Power factor is the ratio of the true power (kw. or wattmeter reading) to the apparent power (kv-a. or product of voltmeter and ammeter readings). The ratio is usually expressed in per cent and cannot be greater than 100%.

Skelp Being Formed for the Manufacture of Lap-welded Pipe from which the larger sizes of Conduit are made

If true power is expressed in kilowatts (kw.) and apparent power as the product of kilovolts (1000 volts) and amperes or kv-a.

$$\text{Power factor (P. F.)} = \frac{\text{kw.}}{\text{kv-a.}}$$

For estimating purposes, power factors can be assumed as follows, except on long transmission lines; incandescent lighting load, no motors, 95%; lighting and motors, 85%; motors only, 80%.

Measurement of Power—If W = watts, E = average volts between line terminals, I = average line current, and P. F. = power factor expressed as a decimal fraction, the following formula represent their relations:

Single-phase $W = EI \times P.F.$
Two-phase $W = 2EI \times P.F.$
Three-phase $W = 1.732\ EI \times P.F.$

Current—From the above formula the current can be found as follows:

Single-phase $I = \frac{W}{E \times P.\,F.}$

Two-phase $I = \frac{W}{2E \times P.\,F.} = \frac{.5\ W}{E \times P.\,F.}$

Three-phase $I = \frac{W}{1.732\ E \times P.\,F.} = \frac{.578\ W}{E \times P.\,F.}$

Effect of Changes of Voltage and Frequency

The starting torque of an induction motor will vary as the square of the voltage applied to the primary: hence, the primary voltage required to produce a given starting torque can be determined by means of the formula:

$$V^1 = V\sqrt{\frac{T^1}{T}}$$

Where V^1 and T^1 signify required voltage and torque respectively, V, the full rated voltage, and T, the starting torque at full voltage. For example: if a squirrel cage induction motor is required to start with full load torque only, and if the starting torque at full voltage is 2.5 times full load torque (2.5 F.L.T.) the starting voltage should be:

$V^1 = V\sqrt{\frac{1}{2.5}} = .63V$; that is, the starting voltage should be 63% of full voltage.

Continued

The starting current of squirrel cage induction motors depends on the starting voltage applied and is independent of the torque required to start the load; the current falls almost immediately, however, to the value corresponding to the required torque and then decreases more gradually as the motor speed accelerates. From this, it follows that the starting voltage should not be greatly in excess of that required for the torque.

Wound rotor motors when started by means of resistance in the secondary circuits can usually be accelerated to full speed with full load torque with current little in excess of full load current.

A variation in either voltage or frequency not exceeding 10% is generally permissible with any induction motor. Such variations are always accompanied by changes from normal performance with either the voltage or the frequency differing from normal; the following performance change will be obtained:

	Effect on			
Character of Change	**Power Factor**	**Torque**	**Slip**	**Efficiency**
Voltage higher	Decreased	Increased	Decreased	Decreased
Voltage lower	Increased	Decreased	Increased	Increased
Frequency higher	Increased	Decreased	% slip unchanged	Increased
Frequency lower	Decreased	Increased	% slip unchanged	Decreased

The voltage and frequency should not be varied simultaneously in opposite directions, that is, one increased and the other decreased, if an induction motor must operate on frequency other than standard, the performance will be better if the voltage is changed in proportion to the square root of the frequency. For example: a 220-volt, 60 cycle motor, operating on 50 cycles, will have very nearly its normal performance if the voltage is decreased to $220 \times \sqrt{\frac{50}{60}} = 200.$

HOW TO USE MOTOR TABLES

The following tables are compiled on a basis of 1 volt loss for convenience in using the table on other percentages of loss. It is usual to allow a loss of more than 1 volt for motor service. In such case, divide the distance by the loss allowed, which will give the number of feet in which a loss of 1 volt will occur. Find this number of feet on the table at the horse power and voltage required and you will have necessary size of wire.

Example—A 5 horse power 220-volt motor, 400 feet from service, at 8 volts loss.

Explanation—A loss of 8 volts for 400 feet would be equal to a loss of 1 volt for 50 feet (400 divided by 8 equals 50). By referring to table we find that to carry a 5 horse power, 220-volt motor, 50 feet with a volt loss, a 6 B. & S. wire is required, which means that the same wire would be required to do the work called for by the example.

Always take the nearest number above rather than below in the table to the number of feet actually required. Do not use a smaller wire than given in following table.

MINIMUM SIZE WIRE FOR MOTOR SERVICE

Horse Power	Size of Wire, B. & S.		
	110 Volts	220 Volts	500 Volts
½	14	14	14
1	14	14	14
2	10	14	14
3	8	12	14
4	6	10	14
5	5	8	14
7½	3	6	12
10	2	5	10
15	00	3	8
20	000	2	6
25	0000	1	5
30	----	00	4
40	----	000	2
50	----	0000	1

AMPERES PER MOTOR

Horse Power	Per Cent of Effi ciency	Watts	Operating Voltage									
			50	75	110	220	400	500	600	800	1000	1200
½	75	497	10.	6.62	4.5	2.25	1.24	1.	.83	.62	.497	.41
¾	75	746	14.9	9.94	6.78	3.38	1.86	1.48	1.24	.93	.746	.62
1	75	995	20.	13.24	9.	4.5	2.5	2.	1.66	1.24	1.	.82
1½	80	1492	29.8	19.8	13.56	6.78	3.73	2.98	2.48	1.86	1.492	1.24
2	80	1865	37.3	24.9	16.9	8.5	4.7	3.8	3.1	2.33	1.9	1.6
3	80	2797	55.9	37.2	25.4	12.7	6.99	5.59	4.66	3.49	2.797	2.33
4	80	3730	74.6	49.8	33.8	16.9	9.3	7.5	6.2	4.66	3.8	3.1
5	80	4662	93.2	62.1	42.3	21.1	11,65	9.32	7.77	5.82	4.662	3.88
7½	90	6217	124.	82.9	56.5	82.2	15.34	12.43	10.36	7.77	6.217	5.18
10	90	8288	165.	110.	75.3	37.6	20.72	16.57	13.81	10.36	8.288	6.9
15	90	12433	248.	165.	113.	56.5	31.08	24.86	20.72	15.54	12.43	10.36
20	90	16578	331.	221.	150.	75.3	41.44	33.15	27.63	20.72	16.57	13.98
25	90	20722	414.	276.	188.	94.1	51.8	41.6	34.5	25.9	20.7	17.2
30	90	24866	497.	331.	226.	113.	62.	49.7	41.4	31.	24.8	20.7
40	90	33155	663.	442.	301.	150.	82.8	66.3	55.2	41.4	33.1	27.6
50	90	41444	828.	552.	376.	188.	103.	82.8	69.	51.8	41.4	34.5
60	90	49733	994.	663.	452.	226.	124.	99.4	82.8	60.	49.7	41.4
70	90	58022	1160.	773.	527.	263.	145.	116.	96.7	72.5	58.	48.3
80	90	66311	1326.	884.	602.	301.	165.	132.	110.	82.9	66.3	55.2
90	90	74599	1491.	994.	678.	339.	186.	149.	124.	93.	74.5	62.
100	90	82888	1657.	1105.	753.	376.	207.	165.	138.	103.	82.8	69.
120	90	99459	1989.	1326.	904.	452.	248.	198.	165.	124.	99.	82.8
150	90	24312	2486.	1657.	1131.	565.	310.	248.	207.	155.	124.	103.

AMPERES PER HORSE POWER IN D. C. MOTORS

Efficiency of Motor

Voltage	75 Per Cent	80 Per Cent	85 Per Cent	90 Per Cent
110	9.	8.4	7.9	7.5
220	4.5	4.2	3.95	3.75
500	1.98	1.86	1.75	1.66

Two Per Cent Loss on 110 Volts

Capacity Amperes	Distance in Feet to Center of Distribution																		
	20	30	40	50	60	70	80	90	100	120	140	160	180	200	240	280	320	360	400
1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	16	15	15	14	14
1.5	....	....	....	....	....	....	....	....	....	....	....	16	15	15	14	14	13	12	12
2	....	....	....	....	....	....	....	....	....	16	15	15	14	14	13	12	12	11	11
3	....	....	....	....	....	....	16	15	15	14	14	13	12	12	11	11	10	9	9
4	....	....	....	....	16	15	15	14	14	13	12	12	11	11	10	9	9	8	8
5	....	....	....	16	15	14	14	13	13	12	11	11	10	10	9	8	8	7	7
6	....	....	16	15	14	14	13	12	12	11	11	10	9	9	8	8	7	7	6
7	....	16	15	14	14	13	12	12	11	11	10	9	9	8	7	7	6	6	5
8	....	16	15	14	13	12	12	11	11	10	9	9	8	8	7	7	6	5	5
9	....	15	14	13	12	12	11	11	10	9	9	8	8	7	7	6	5	5	4
10	16	15	14	13	12	11	11	10	10	9	8	8	7	7	6	5	5	4	4
12	16	14	13	12	11	11	10	9	9	8	8	7	7	6	5	5	4	4	3
14	15	14	12	11	11	10	9	9	8	7	7	6	6	5	5	4	3	3	2
16	15	13	12	11	10	9	9	8	8	7	7	6	5	5	4	3	3	2	2
18	14	12	11	10	9	9	8	8	7	7	6	5	5	4	4	3	2	2	1
20	14	12	11	10	9	8	8	7	7	6	5	5	4	4	3	2	2	1	1
25	13	11	10	9	8	7	7	6	6	5	4	4	3	3	2	1	1	0	0
30	12	10	9	8	7	7	6	6	5	4	4	3	3	2	1	1	0	0	00
35	11	10	8	7	7	6	5	5	4	4	3	2	2	1	1	0	00	00	000
40	11	9	8	7	6	5	5	4	4	3	2	2	1	1	0	00	00	000	000
45	10	9	7	6	6	5	4	4	3	3	2	1	1	0	00	00	000	000	0000
50	10	8	7	6	5	4	4	3	3	2	1	1	0	0	00	000	000	0000	0000
60	9	7	6	5	4	4	3	3	2	1	1	0	0	00	000	000	0000	0000	....
70	8	7	5	4	4	3	2	2	1	1	0	00	00	000	000	0000	0000	....	....
80	8	6	5	4	3	2	2	1	1	0	00	00	000	000	0000	0000	....	....	....
90	7	6	4	3	3	2	1	1	0	00	00	000	000	0000	0000	....	....	....	....
100	7	5	4	3	2	1	1	0	0	00	000	000	0000	0000	....	....	....	....	....
120	6	4	3	2	1	1	0	0	00	00	000	0000	0000	....	....	....	....	....	....

Two Per Cent Loss on 220 Volts

Cap.	Distance in Feet to Center of Distribution																		
Ampr.	20	30	40	50	60	70	80	90	100	120	140	160	180	200	240	250	320	360	400
1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	16
1.5	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	16	15	15
2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	16	15	15	14	14
3	....	....	....	....	....	....	....	....	....	....	....	16	15	15	14	14	13	12	12
4	....	....	....	....	....	....	....	....	....	16	15	15	14	14	13	12	12	11	11
5	....	....	....	....	....	....	....	....	16	15	14	14	13	13	12	11	11	10	10
6	....	....	....	....	....	....	16	15	15	14	14	13	12	12	11	11	10	9	9
7	....	....	....	....	....	16	15	14	14	14	13	12	12	11	11	10	9	9	8
8	....	....	....	....	16	15	15	14	14	13	12	12	11	11	10	9	9	8	8
9	....	....	....	....	15	15	14	14	13	12	12	11	11	10	9	9	8	8	7
10	....	....	....	16	15	14	14	13	13	12	11	11	10	10	9	8	8	7	7
12	....	....	16	15	14	14	13	12	12	11	11	10	9	9	8	8	7	7	6
14	....	16	15	14	14	13	12	12	11	11	10	9	9	8	7	7	6	6	5
16	....	16	15	14	13	12	12	11	11	10	9	9	8	8	7	7	6	6	5
18	....	15	14	13	12	12	11	11	10	9	9	8	8	7	7	6	5	5	4
20	16	15	14	13	12	11	11	10	10	9	8	8	7	7	6	5	5	4	4
25	16	14	13	12	11	10	10	9	9	8	7	7	6	6	5	4	4	3	3
30	15	13	12	11	10	10	9	9	8	7	7	6	6	5	4	4	3	3	2
35	14	13	11	10	10	9	8	8	7	7	6	5	5	4	4	3	2	2	1
40	14	12	11	10	9	8	8	7	7	6	5	5	4	4	3	2	2	1	1
45	13	12	10	9	9	8	7	7	6	6	5	4	4	3	3	2	1	1	0
50	13	11	10	9	8	7	7	6	6	5	4	4	3	3	2	1	1	0	0
60	12	10	9	8	7	7	6	6	5	4	4	3	3	2	1	1	0	0	00
70	11	10	8	7	7	6	5	5	4	4	3	2	2	1	1	0	00	00	000
80	11	9	8	7	6	5	5	4	4	3	2	2	1	1	0	00	00	000	000
90	10	9	7	6	6	5	4	4	3	3	2	1	1	0	00	00	000	000	0000
100	10	8	7	6	5	4	4	3	3	2	1	1	0	0	00	000	000	0000	0000
120	9	7	6	5	4	4	3	3	2	1	1	0	0	00	000	000	0000	0000	.. ..

Wire sizes given are B. & S.

GENERAL WIRING FORMULA

For A.C. and D.C. Circuits

The following general formula may be used to determine the size of copper conductors, volts loss in lines, current per conductor, and of copper per circuit for any system of electrical distribution.

Area of conductor, circular mils $= \frac{D \times W \times K}{P \times E^2}$

Volts loss in lines $= \frac{P \times E \times M}{100}$

Current in main conductors $= \frac{W \times T}{E}$

Pounds copper $= \frac{D^2 \times W \times K \times A}{P \times E^2 \times 1000000}$

W = Total watts delivered.

D = Distance of transmission (1 way) in feet.

P = Loss in line in per cent of power delivered, that is, of W.

E = Voltage between main conductors at receiving or consumer's end of circuit.

For continuous current K=2160, T=1, M=1, and A=6.04.

		Per Cent Power Factor				
		Value of K				
System	Value of A	100	95	90	85	80
Single-Phase	6.04	2160	2400	2660	3000	3380
Two-Phase (4-Wire)	12.08	1080	1200	1330	1500	1690
Three-Phase (3-Wire)	9.06	1080	1200	1330	1500	1690

	Per Cent Power Factor				
	Value of T				
System	100	95	90	85	80
Single-Phase	1.00	1.05	1.11	1.17	1.25
Two-Phase (4-Wire)	.50	.53	.55	.59	.62
Three-Phase (3-Wire)	.58	.61	.64	.68	.72

	Per Cent Power Factor							
	Value of M—Wires 18 Inches Apart							
	25 Cycles				60 Cycles			
Wire Sizes	0.95	0.90	0.85	0.80	0.95	0.90	0.85	0.80
0000	1.17	1.16	1.12	1.06	1.53	1.64	1.67	1.66
000	1.12	1.09	1.05	.99	1.41	1.49	1.50	1.47
00	1.08	1.04	.99	.92	1.32	1.36	1.35	1.31
0	1.05	1.00	.94	.87	1.24	1.26	1.24	1.19
1	1.02	.96	.90	.83	1.18	1.17	1.14	1.08
2	1.00	.93	.86	.79	1.12	1.10	1.06	1.00
3	.98	.91	.84	.76	1.08	1.05	.99	.93
4	.96	.89	.81	.74	1.05	1.00	.94	.87
5	.95	.88	.80	.72	1.02	.97	.90	.83
6	.94	.86	.78	.70	1.00	.94	.87	.79
7	.94	.85	.77	.69	.98	.91	.84	.76
8	.93	.85	.76	.68	.97	.89	.82	.74
9	.92	.84	.76	.67	.95	.88	.80	.72
10	.92	.83	.75	.67	.94	.86	.79	.71

GENERAL WIRING FORMULA

For A.C. and D.C. Circuits

The value of K for any particular power factor is obtained by dividing 2160, the value for continuous current, by the square of that power factor for single-phase, and by twice the square of that power factor for 3-wire 3-phase, or 4-wire 2-phase.

The value of M depends on the size of wire, frequency and power factor.

The figures given are for wires 18 inches apart and are sufficiently accurate for all practical purposes provided the displacement in phase between current and E. M. F. at the receiving end is not much greater than that at the generator. For example, the constants should not be applied at 125 cycles if the largest conductors are used and the loss 20 per cent or more of the power delivered. At lower frequencies, however, the constants are reasonably correct even under such extreme conditions. They represent about the true values at 10 per cent line loss, are close enough at all losses less than 10 per cent, and often, at least for frequencies up to 40 cycles, close enough for even much larger losses. Where the conductors of a circuit are nearer each other than 18 inches, the volts loss will be less than given by the formula, and if close together, as with multiple conductor cable, the loss will be only that due to resistance.

The value of T depends on the system and power factor. It is equal to 1 for continuous current and for single-phase current of 100 per cent power factor.

The value of A and the weights of the wires in the table are based on .00000302 pound as the weight of a foot of copper wire of 1 circular mil area.

In using the above formula and constants, it should be particularly observed that P stands for the per cent loss in the line of the delivered power, not for the per cent loss in the line of the power at the generator; and that E is the potential at the end of the line and not at the generator.

When the power factor cannot be more accurately determined, it may be assumed to be as follows for any alternating system operating under average conditions: Incandescent lighting and synchronous motors, 95 per cent; lighting and induction motors together, 85 per cent; induction motors alone, 80 per cent.

In continuous current 3-wire systems, the neutral wire for feeders should be made of 1/3 the section obtained by the formula for either of the outside wires. In both continuous and a.c. systems, the neutral conductor for secondary mains and house wiring should be taken as large as the other conductors. The 3 wires of a 3-phase circuit and the 4 wires of a 2-phase circuit should be made all the same size, and each conductor should be of the cross section given by the first formula.

GENERAL WIRING FORMULA

For A.C. and D.C. Circuits

25 Cycles

Size of Wire B.&S.	Area Wire Cir. Mils	Wt., Lbs. Bare Wire per 1000 Ft.	Resistance Ohms per 1000 Ft. at 20° C.	Value of B Per Cent Power Factor			
				95	90	85	80
0000	211600	640.73	.04879	1.23	1.29	1.33	1.34
000	167805	508.12	.06154	1.18	1.22	1.24	1.24
00	133079	402.97	.07758	1.14	1.16	1.16	1.16
0	105560	319	.09775	1.10	1.11	1.10	1.09
1	83694	253.43	.1234	1.07	1.07	1.05	1.03
2	66373	200.98	.1556	1.05	1.04	1.02	1
3	52633	159.38	.1962	1.03	1.02	1	1
4	41742	126.40	.2473	1.02	1	1	1
5	33102	100.23	.3120	1	1	1	1
6	26250	79.49	.3934	1	1	1	1
7	20816	63.03	.4959	1	1	1	1
8	16509	49.99	.6250	1	1	1	1
9	13090	39.60	.7886	1	1	1	1
10	10382	31.40	.9940	1	1	1	1

40 Cycles

Size of Wire B.&S.	Area Wire Cir. Mils	Wt., Lbs. Bare Wire per 1000 Ft.	Resistance Ohms per 1000 Ft. at 20° C.	Value of B Per Cent Power Factor			
				95	90	85	80
0000	211600	640.73	.04879	1.52	1.53	1.61	1.67
000	167805	508.12	.06154	1.40	1.41	1.48	1.51
00	133079	402.97	.07758	1.25	1.32	1.35	1.73
0	105560	319	.09775	1.19	1.24	1.26	1.26
1	83694	253.43	.1234	1.14	1.17	1.18	1.17
2	66373	200.98	.1556	1.11	1.12	1.12	1.10
3	52633	159.38	.1962	1.07	1.08	1.07	1.05
4	41742	126.40	.2473	1.05	1.06	1.03	1
5	33102	100.23	.3120	1.03	1.01	1	1
6	26250	79.49	.3934	1.02	1	1	1
7	20816	63.03	.4959	1.01	1	1	1
8	16509	49.99	.6250	1	1	1	1
9	13090	39.60	.7886	1	1	1	1
10	10382	31.40	.9940	1	1	1	1

✓

GENERAL WIRING FORMULA

60 Cycles

Size of Wire B.&S.	Area Wire Cir. Mils	Wt., Lbs. Bare Wire per 1000 Ft.	Resistance Ohms per 1000 Ft. at 20° C.	VALUE OF B PER CENT POWER FACTOR			
				95	90	85	80
0000	211600	640.73	.04879	1.62	1.84	1.99	2.09
000	167805	508.12	.06154	1.49	1.66	1.77	1.95
00	133079	402.97	.07758	1.34	1.52	1.60	1.66
0	105560	319	.09775	1.31	1.40	1.46	1.49
1	83694	253.43	.1234	1.24	1.30	1.34	1.36
2	66373	200.98	.1556	1.18	1.23	1.25	1.26
3	52633	159.38	.1962	1.14	1.17	1.18	1.17
4	41742	126.40	.2473	1.11	1.12	1.11	1.10
5	33102	100.23	.3120	1.08	1.08	1.06	1.04
6	26250	79.49	.3934	1.05	1.04	1.02	1
7	20816	63.03	.4958	1.03	1.02	1	1
8	16509	49.99	.6250	1.02	1	1	1
9	13090	39.60	.7886	1	1	1	1
10	10382	31.40	.9940	1	1	1	1

125 Cycles

Size of Wire B.&S.	Area Wire Cir. Mils	Wt., Lbs. Bare Wire per 1000 Ft.	Resistance Ohms per 1000 Ft. at 20° C.	VALUE OF B PER CENT POWER FACTOR			
				95	90	85	80
0000	211600	640.73	.04879	2.35	2.86	3.24	3.49
000	167805	508.12	.06154	2.08	2.48	2.77	2.94
00	133079	402.97	.07758	1.86	2.18	2.40	2.57
0	105560	319	.09775	1.71	1.96	2.13	2.25
1	83694	253.43	.1234	1.56	1.75	1.88	1.97
2	66373	200.98	.1556	1.45	1.60	1.70	1.77
3	52633	159.38	.1962	1.35	1.46	1.53	1.57
4	41742	126.40	.2473	1.27	1.35	1.40	1.43
5	33102	100.23	.3120	1.21	1.27	1.30	1.31
6	26250	79.49	.3934	1.16	1.20	1.21	1.21
7	20816	63.03	.4958	1.12	1.14	1.14	1.13
8	16509	49.99	.6250	1.09	1.10	1.09	1.07
9	13090	39.60	.7886	1.06	1.06	1.04	1.02
10	10382	31.40	.9940	1.04	1.03	1	1

WIRING DATA FOR A.C. MOTORS

3-Phase

H.P.	Approx. Full Load Current—Amperes				Starting Fuse —Amperes				Running Fuse —Amperes				Minimum Size Wire (B. & S. Gauge) Rubber or Other Insulation				Size of Conduit Underwriters				Capacity of Unfused Switch —Amperes				Capacity of Single Throw Fused Switch† —Amperes			
	110 V.	220 V.	440 V.	550 V.	110 V.	220 V.	440 V.	550 V.	110 V.	220 V.	440 V.	550 V.	110 V.	220 V.	440 V.	550 V.	110 V.	220 V.	440 V.	550 V.	110 V.	220 V.	440 V.	550 V.	110 V.	220 V.	440 V.	550 V.
¼	2.4	1.2	0.6	.5	6	5	5	5	3	2	1	1.0	14	14	14	14	½	½	½	½	30	30	30	30	30	30	30	30
½	4.4	2.2	1.1	.9	10	5	5	5	5	3	2	1.5	14	14	14	14	½	½	½	½	30	30	30	30	30	30	30	30
¾	6.2	3.1	1.6	1.25	15	8	5	5	9	4	3	2	14	14	14	14	½	½	½	½	30	30	30	30	30	30	30	30
1	8	4	2	1.6	20	10	5	5	10	6	3	3	14	14	14	14	½	½	½	½	30	30	30	30	30	30	30	30
1½	10.3	5.1	2.6	2.1	25	15	7	6	15	8	4	3	12	14	14	14	¾	½	½	½	30	30	30	30	30	30	30	30
2	12.5	6.25	3.2	2.5	30	20	15	10	20	10	6	4	10	12	14	14	¾	¾	½	½	30	30	30	30	30	30	30	30
3	18	9	4.5	3.6	50	30	20	10	25	15	10	5	8	10	14	14	1	¾	½	½	30	30	30	30	60	30	30	30
4	24	12	6	4.8	60	30	20	15	35	15	10	6	6	10	14	14	1¼	¾	½	½	30	30	30	30	60	30	30	30
5	30	15	7.5	6	70	40	25	15	40	20	10	10	6	8	12	14	1¼	1	¾	½	30	30	30	30	100	60	30	30
7½	44	22	11	8.8	90	60	30	25	60	30	15	15	4	6	10	12	1¼	1¼	¾	¾	60	30	30	30	100	60	30	30
10	58	29	14.5	12	120	70	40	30	75	40	20	20	2	6	8	10	1½	1¼	1	¾	60	30	30	30	200	100	60	30
15	82	41	20.5	16.5	170	85	50	40	125	50	30	25	0	4	8	8	2	1¼	1	1	100	60	30	30	200	100	60	60
20	110	55	27.5	22	220	110	60	55	150	70	35	30	00	2	6	6	2	1½	1¼	1¼	200	60	30	30	400	200	60	60
25	136	68	34	27.2	270	140	70	65	175	80	40	35	000	1	6	6	2	1½	1¼	1¼	200	100	60	30	400	200	100	100
30	160	80	40	32	320	160	80	70	200	100	50	40	*211	0	4	6	2½	2	1¼	1¼	200	100	60	60	400	200	100	100
35	188	94	46.5	37	375	190	100	75	225	120	60	45	300	0	2	4	3	2	1½	1¼	200	100	60	60	400	200	100	100
40	212	106	53	42.5	420	210	110	85	275	140	75	50	350	00	2	4	3	2	1½	1¼	400	200	60	60	600	400	200	100
50	264	132	66	53	520	260	125	110	325	160	90	60	450	000	1	2	3	2	1½	1½	400	200	100	60	600	400	200	200
60	316	158	79	63	620	310	160	125	400	180	100	70	550	*211	0	2	3½	2½	2	1½	400	200	100	100	800	400	200	200
75	392	196	98	78.5	770	390	175	160	475	250	125	90	750	300	0	0	3½	3	2	2	400	200	100	100	800	400	200	200
100	.....	254	130	100.4	...	500	250	200	...	325	160	125	....	400	000	0	...	3	2	2	...	400	200	200	....	600	400	200
125	.....	318	159	127	...	650	310	250	...	400	200	150	....	600	0000	000	...	3½	2½	2	...	400	200	200	....	800	400	400
150	.....	380	190	152	...	730	370	300	...	450	250	175	....	700	*300	*200	...	3½	3	2½	...	400	200	200	....	800	400	400
175	.....	445	223	178	...	850	440	350	...	500	275	225	....	900	350	250	...	4	3	2½	...	600	400	200	....	1200	600	400
200	.....	510	255	204	...	920	480	390	...	600	300	250	....	900	400	300	...	4	3	3	...	600	400	400	....	1200	600	400
250	.....	595	287	240	...	200	570	480	...	650	1315	265	..	1300	500	400	...	5	3	3	...	600	400	400	....	1200	600	600
300	.....	710	355	285	...	420	710	570	...	780	1390	315	..	1600	650	500	...	5	3½	3	...	800	400	400	....	1800	800	600

WIRING DATA FOR A.C. MOTORS

Single Phase

¼	4	2	1	.8	10	5	5	5	5	3	2	1	14	14	14	14	½	½	½	½	30	30	30	30	30	30	30	30
½	7.5	3.7	1.8	1.3	20	10	5	5	10	5	2	2	14	14	14	14	½	½	½	½	30	30	30	30	30	30	30	30
¾	10	5	2.5	2	25	15	8	5	12	6	3	3	12	14	14	14	½	½	½	½	30	30	30	30	30	30	30	30
1	12.5	6.1	3.1	2.4	35	20	10	5	15	10	4	3	8	14	14	14	¾	½	½	½	30	30	30	30	60	30	30	30
1½	18	9	4.5	3.6	50	25	12	10	20	10	5	4	8	12	14	14	¾	½	½	½	30	30	30	30	60	30	30	30
2	24	12	6	4.8	65	35	20	15	30	15	10	5	6	8	14	14	1	¾	½	½	30	30	30	30	100	60	30	30
3	34	17	8.5	6.8	75	45	30	25	40	20	15	10	4	8	10	12	1¼	¾	¾	½	60	30	30	30	100	60	30	30
4	43	22	11	8.6	90	60	30	25	50	25	15	10	4	6	10	12	1¼	1	¾	½	60	30	30	30	100	60	30	30
5	55	28	14.6	11.7	120	70	40	30	65	35	20	15	2	6	8	10	1¼	1	¾	¾	60	30	30	30	200	100	60	30
7½	80	40	20	16	170	85	55	45	95	45	25	20	0	4	6	8	1½	1¼	1	¾	100	60	30	30	200	100	60	60
10	105	53	26.5	21.1	220	110	70	60	120	60	30	25	00	2	6	6	2	1¼	1	1	200	60	30	30	400	200	100	60
15	162	81	40.5	33	325	165	80	70	180	90	45	35	*211	0	4	6	2	1½	1¼	1	200	100	60	60	400	200	100	100
20	208	104	52	42.6	400	200	110	85	230	115	60	45	300	0	2	4	2½	1½	1¼	1¼	400	200	60	60	400	200	200	100
25	258	129	64.5	51.6	500	260	135	100	280	140	70	60	400	000	1	2	3	2	1½	1¼	400	200	100	60	600	400	200	100
30	304	152	76	61	600	300	150	125	335	170	85	70	500	*200	0	2	3	2	1½	1¼	400	200	100	100	600	400	200	200
35	356	178	89	70	710	360	180	140	380	190	100	80	650	300	0	1	3½	2½	1½	1½	400	200	100	100	800	400	200	200
40	400	200	100	80	800	400	200	160	440	220	110	90	750	300	0	0	3½	2½	1½	1½	400	200	100	100	800	400	200	200
50	492	246	123	99	980	590	250	200	540	270	135	110	1000	500	000	0	4	3	2	1½	600	400	200	100	1200	600	400	200.

Wiring Data for A.C. Motors

2-Phase, 4-Wire

H.P.	Approx. Full Load Current Amperes				Starting Fuse –Amperes				Running Fuse –Amperes				Minimum Size Wire (B. & S. Gauge) Rubber or Other Insulation				Size of Conduit Underwriters				Capacity of Unfused Switch –Amperes				Capacity of Single Throw Fused Switch† –Amperes			
	110 V.	220 V.	440 V.	550 V.	110 V.	220 V.	440 V.	550 V.	110 V.	220 V.	440 V.	550 V.	110 V.	220 V.	440 V.	550 V.	110 V.	220 V.	440 V.	550 V.	110 V.	220 V.	440 V.	550 V.	110 V.	220 V.	440 V.	550 V.
¼	2	1	.5	.45	5	5	5	5	3	2	1	1	14	14	14	14	¾	¾	¾	¾	30	30	30	30	30	30	30	30
½	3.8	1.9	.95	.72	10	5	5	5	5	3	2	1.5	14	14	14	14	¾	¾	¾	¾	30	30	30	30	30	30	30	30
¾	5.5	2.8	1.35	1.1	15	7	5	5	7	4	3	2	14	14	14	14	¾	¾	¾	¾	30	30	30	30	30	30	30	30
1	7	3.5	1.75	1.4	15	10	5	5	10	5	3	2	14	14	14	14	¾	¾	¾	¾	30	30	30	30	30	30	30	30
1½	8.8	4.5	2.25	1.8	20	12	6	5	10	7	4	3	14	14	14	14	¾	¾	¾	¾	30	30	30	30	30	30	30	30
2	11	5.5	2.75	2.2	30	15	10	5	15	10	4	4	10	14	14	14	1	¾	¾	¾	30	30	30	30	30	30	30	30
3	15.8	7.9	4	3.2	40	25	15	10	20	10	6	5	8	12	14	14	1	¾	¾	¾	30	30	30	30	60	30	30	30
4	21	10.5	5.03	4.25	60	30	15	12	30	15	25	6	6	10	14	14	1¼	1	¾	¾	30	30	30	30	60	30	30	30
5	26.2	13.1	6.6	5.25	70	35	20	15	35	20	10	10	6	8	14	14	1¼	1	¾	¾	30	30	30	30	100	60	30	30
7½	38.6	19.3	9.7	7.75	80	50	30	20	50	25	15	10	4	8	10	14	1½	1	1	¾	60	30	30	30	100	60	30	30
10	50.8	25.4	12.7	10.5	100	65	35	30	60	35	20	15	2	6	8	10	1½	1¼	1	1	60	30	30	30	100	100	60	30
15	72	36	18	14.5	150	75	45	40	90	50	25	20	0	5	8	8	2	1¼	1	1	100	60	30	30	200	100	60	60
20	96	48	24	19.2	190	95	60	50	125	60	30	25	0	3	6	8	2	1½	1¼	1	100	60	30	30	200	100	60	60
25	120	60	30	24	240	120	70	60	150	75	40	30	000	2	6	6	2½	1½	1¼	1¼	200	60	30	30	400	200	100	60
30	140	70	35	28	280	140	75	65	175	85	45	35	*200	1	5	6	2½	2	1¼	1¼	200	100	60	30	400	200	100	100
35	163	81	40	32.5	320	160	80	70	200	100	50	40	211	0	5	6	2½	2	1¼	1¼	200	100	60	60	400	200	100	100
40	184	92	46	37	360	180	90	75	225	110	60	45	300	0	4	5	3	2	1½	1¼	200	100	60	60	400	200	100	100
50	230	115	57.5	46	450	225	110	90	275	140	70	55	350	00	2	4	3½	2½	1½	1½	400	200	60	60	600	400	200	100
60	276	138	69	55	540	270	135	110	350	165	85	65	450	000	1	2	3½	2½	2	1½	400	200	100	60	600	400	200	200
75	314	172	86	69	660	330	170	130	400	200	100	80	600	*211	0	1	4	2½	2	2	400	200	100	100	800	400	200	200
100	.....	227	114	91	...	440	220	175	...	275	135	100	....	350	00	0	...	3½	2½	2	...	400	200	100	....	600	400	200
125	.....	278	139	111	...	560	280	220	...	350	175	125	....	500	*200	00	...	3½	2½	2½	...	400	200	200	....	600	400	400
150	.....	333	167	133	...	640	320	260	...	400	200	150	....	550	211	000	...	4	2½	2½	...	400	200	200	....	800	400	400
175	.....	390	195	156	...	780	400	320	...	450	225	175	....	800	300	*211	...	4½	3	2½	...	400	200	200	....	800	400	400
200	.....	446	223	178	...	830	420	340	...	525	250	200	....	800	350	250	...	4½	3½	3	...	600	400	200	....	1200	600	400

*Thousands Circular Mills. †When motor is so connected that the fuses are cut out of the circuit during the starting period, a fused switch may be used of the standard size necessary to take the fuse given in the table headed "Running Fuse."

For "Across the Line Starters" increase wire size and starting fuse 25%. Conduit size increased to correspond to wire size.

FULL LOAD CURRENTS OF MOTORS

D.C. Motors

H.P. Motor	Volts			H.P. Motor	Volts		
	115	230	550		115	230	550
½	4.5	2.3	....	**20**	149	74	31
¾	6.5	3.3	1.4	**25**	185	92	38
1	8.4	4.2	1.7	**30**	220	110	45
1½	12.5	6.3	2.6	**40**	294	146	61
2	16.1	8.3	3.4	**50**	364	180	75
3	23	12.3	5.0	**60**	436	215	90
5	40	19.8	8.2	**75**	540	268	111
7½	58	28.6	12	**100**		357	146
10	75	38	16	**125**		440	184
15	112	56	23	**150**	...	...	220

Single-Phase Type SCR Motors

H.P. Motor	Volts		H.P. Motor	Volts		H.P. Motor	Volts	
	110	220		110	220		110	220
¼	7.6	3.8	**1½**	15.0	7.5	**7½**	67.6	33.8
½	8.0	4.0	**2**	20.0	10.0	**10**	86.0	43.0
¾	9.6	4.8	**3**	27.8	13.9			
1	11.0	5.5	**5**	46.6	23.3	.	...	...

Shearing and forming Skelp
to be used in the manufacture of Butt Weld pipe

FULL LOAD CURRENTS OF MOTORS

Squirrel-Cage A.C. Induction Motors
2-Phase

H.P. Motor	Volts				
	110	220	440	550	2200
½	4.1	2.1	1.0	0.9	....
¾	4.8	2.4	1.2	1.0	....
1	5.6	2.8	1.4	1.1	....
1½	7.8	3.9	2.0	1.7	....
2	9.7	4.9	2.4	2.0	....
3	....	7.8	3.9	3.1	....
5	....	13	6.5	5.2	....
7½	....	19	9.5	7.6	....
10	....	24	11.3	9.4	....
15	....	33	16.5	13.2	....
20	....	45	22.5	18.2	5.0
25	....	56	27.7	22.2	6.4
30	....	67	33.5	27.0	7.4
40	....	88	44	35.5	9.5
50	....	109	54	43.5	12.1
60	....	129	65	52	13.5
75	....	156	78	62.5	16.7
100	....	213	107	87	21.7
125	....	270	134	109	27.0
150	....	.....	156	125	31.2
200	....	.....	217	173	43.3
250	....	.....	265	213	54.0
300	....	.....	320	255	63.2
400	....	.....	440	355	88.5
450	....	.....	520	416	95.2
500	....	.....	540	433	109
600	....	.....	655	525	130
750	....	.....	800	640	160

View in Butt Weld Tube Mill

FULL LOAD CURRENTS OF MOTORS

Squirrel-Cage A.C. Induction Motors

H. P. Motor	Volts				
	3-Phase				
½	4.8	2.4	1.2	1.0	....
¾	5.6	2.8	1.4	1.1	....
1	6.4	3.2	1.6	1.3	....
1½	9.0	4.5	2.3	1.9	....
2	11.2	5.6	2.8	2.3	....
3	....	9	4.5	3.6	....
5	....	15	7.5	6.0	....
7½	....	22	11.0	8.8	....
10	....	27	13.5	10.8	....
15	....	38	19.0	15.2	....
20	....	52	26.0	21.0	5.7
25	....	64	32.0	25.6	7.4
30	....	77	38.5	31	8.5
40	....	101	50.5	41	11.0
50	....	125	62.5	50	14.0
60	....	149	74.5	60	15.5
75	....	180	90	72	19.2
100	....	246	123	100	25
125	....	310	155	124	31
150	....	.....	180	144	36
200	....	.....	250	200	50
250	....	.....	305	245	62
300	....	.....	368	295	73
400	....	.....	508	410	102
450	....	.....	600	480	110
500	....	.....	625	500	125
600	....	.....	756	605	150
750	....	.....	925	740	185

Skelp Passing Through Bell in which it is Formed and Welded into Butt Welded Pipe

FULL LOAD CURRENTS OF MOTORS

Slip-Ring A.C. Induction Motors

The following data are approximate full-load currents for motors of various types, frequencies and speeds. They have been compiled from average values for representative motors of their respective classes. Variations of 10 per cent above or below the values given may be expected.

2-Phase

H.P. Motor	Volts				
	110	220	440	550	2200
1/4	....	.....	......	.....	.....
1/2	....	.....	......	.....	....
3/4	6.2	3.1	1.6	1.3	...
1	6.7	3.4	1.7	1.4	.....
1½	11.7	5.9	3.0	2.3	....
2	12.5	6.3	3.1	2.5	.....
3	....	8.7	4.3	3.5	.....
5	....	13.0	6.5	5.2	.....
7½	....	20.0	10.0	7.6	.....
10	....	24.3	12.1	10.0	.....
15	....	39	19.5	15.6	.....
20	....	49	24.7	19.8	.....
25	....	60	30.0	24.0	6.4
30	....	72	36.0	28.8	7.8
40	....	93	46.5	37.3	9.5
50	....	113	57	45	12.1
60	....	135	68	54	14.0
75	....	164	82	65	17.3
100	....	214	108	87	21.7
125	....	267	134	108	27
150	....	315	158	127	32
175	....	.....	......	.....	....
200	....	430	216	173	44
225	....	.....	......	.....	.....
250	....	535	268	214	55
275	....	.....	......	.....	.....
300	....	654	325	260	65
350	....	.....	....	.....	.....
400	....	.....	430	343	85
450	....	.....	502	402	100
500	....	.....	537	430	109
600	....	.....	660	528	132
750	....	.....	797	636	150
1000	....	.....	1070	852	214

FULL LOAD CURRENTS OF MOTORS

Slip-Ring A.C. Induction Motors

3-Phase

H.P. Motor	Volts				
	110	**220**	**440**	**550**	**2200**
¼	....	....	.....	.....	.....
½	....	....	.....	.....	.....
¾	7.2	3.6	1.8	1.5	.....
1	7.8	3.9	2.0	1.6	.....
1½	13.6	6.8	3.4	2.7	.....
2	14.4	7.2	3.6	2.9	.....
3	....	10	5.0	4.0	.....
5	....	15	7.5	6.0	.....
7½	....	23	11.5	8.8	....
10	....	28	14.0	11.2	.....
15	....	45	22.5	18.0	.....
20	....	57	28.5	22.8	.....
25	....	69	34.5	27.6	7.4
30	....	83	41.5	33.2	9
40	....	107	53.5	43	11
50	....	131	65.5	52	14
60	....	156	78.0	62	16
75	....	189	94.5	75	20
100	....	247	124	100	25
125	....	308	154	123	31
150	....	364	182	146	37
175	....	.....	.....	.....	.....
200	....	498	249	200	51
225	....	.....	.....	.....	.....
250	....	616	308	246	63
275	....	.....	.....	.....	.....
300	....	750	375	300	75
350	....	.....	.....	.....	....
400	....	.....	495	396	98
450	....	.....	580	465	115
500	....	.....	620	496	125
600	....	.....	760	608	152
750	....	.....	920	735	185
1000	....	.....	1230	985	245

AMPERES IN ALTERNATING CURRENT CIRCUITS

By Permission of the Electrical World

The following tables give the amperes per lead wire per kilowatt for single-phase and three-phase balanced loads. The single-phase table can be used for two-phase balanced loads by using a current value corresponding to twice the stated potential of the circuit or by dividing the current value at the potential of the circuit by two. That is, each wire of a two-phase circuit carries one half of the current indicated at the load specified. These tables show the value of the current at power factors varying from unity to 70 per cent. The power of any circuit in kilowatts can, therefore, be computed by dividing the reading of the ammeter by the tabulated value corresponding to the measured power factor and voltage of the circuit. These values are correct only for a balanced load (and there is generally a slight unbalancing of the loads on the phases), but the table is useful in computing the sizes of wire required for transmission purposes.

This table was derived from the following formulas:

For single-phase circuits: Amperes per wire = watts ÷ (volts × power factor).

For three-phase circuits: Amperes per wire = total watts ÷ (volts between wires × power factor—x $\sqrt{3}$).

For two-phase circuits: Amperes per wire = total watts ÷ (volts between wires of one phase × power factor × 2).

In making the computations the number of watts was assumed as 1000, and the amperes were computed for various values of e.m.f. to a sufficient number of decimal places to insure accuracy. The tables were then extended by multiplication and division. If desired, these tables can be further extended to cover voltages outside of their limits by using the tabular values corresponding to potentials of one tenth (or 10 times) the desired potential, care being used to shift the decimal point in the proper direction.

The values for intermediate power factors can be approximated from the tables. For lower power factors, the value of the current for unity power factor can be divided by actual power factor of the circuit or multiplied by the reciprocal of this power factor.

AMPERES IN ALTERNATING CURRENT CIRCUITS

Single-phase Circuits

Amperes for One Kilowatt at Different Power Factors

Volts	Power Factor in per Cent						
	100	**95**	**90**	**85**	**80**	**75**	**70**
100	10.0000	10.5263	11.1111	11.7647	12.5000	13.3333	14.2850
110	9.0909	9.5693	10.1010	10.9652	11.3636	12.1211	12.9870
115	8.6957	9.1533	9.6619	10.2302	10.8696	11.5942	12.4224
120	8.3333	8.7719	9.2592	9.8040	10.4166	11.1111	11.9049
125	8.0000	8.4211	8.8889	9.4118	10.0000	10.6667	11.4286
130	7.6923	8.0972	8.5470	9.0498	9.6154	10.2564	10.9890
140	7.1429	7.5188	7.9365	8.4034	8.9285	9.5238	10.2040
150	6.6667	7.0176	7.4074	7.8431	8.3333	8.8889	9.5239
160	6.2500	6.5790	6.9444	7.3529	7.8125	8.3333	8.9286
170	5.8824	6.1919	6.5360	6.9205	7.3530	7.8431	8.4034
180	5.5556	5.8480	6.1729	6.5359	6.9445	7.4074	7.9366
190	5.2632	5.5402	5.8480	6.1919	6.5790	7.0176	7.5189
200	5.0000	5.2632	5.5556	5.8824	6.2500	6.6667	7.1429
210	4.7619	5.0125	5.2910	5.6022	5.9524	6.3492	6.8027
220	4.5455	4.7847	5.0505	5.3476	5.6819	6.0606	6.4936
225	4.4444	4.6784	4.9382	5.2288	5.5556	5.9259	6.3492
230	4.3479	4.5766	4.8309	5.1151	5.4349	5.7971	6.2113
240	4.1667	4.3860	4.6296	4.9020	5.2084	5.5556	5.9524
250	4.0000	4.2105	4.4444	4.7059	5.0000	5.3333	5.7143
300	3.3333	3.5088	3.7037	3.9216	4.1666	4.4444	4.7614
330	3.0303	3.1897	3.3670	3.5651	3.7879	4.0404	4.3290
350	2.8572	3.0075	3.1746	3.3613	3.5715	3.8095	4.0817
400	2.5000	2.6316	2.7778	2.9412	3.1250	3.3333	3.5714
440	2.2727	2.3923	2.5252	2.6738	2.8409	3.0303	3.2467
450	2.2222	2.3392	2.4691	2.6144	2.7778	2.9630	3.1746
500	2.0000	2.1053	2.2222	2.3529	2.5000	2.6667	2.8571
550	1.8182	1.9139	2.0202	2.1390	2.2728	2.4242	2.5974
600	1.6667	1.7544	1.8519	1.9608	2.0834	2.2222	2.3810
700	1.4286	1.5037	1.5873	1.6807	1.7857	1.9048	2.0409
800	1.2500	1.3158	1.3889	1.4706	1.5625	1.6667	1.7857
900	1.1111	1.1696	1.2345	1.3072	1.3889	1.4815	1.5873
1000	1.0000	1.0527	1.1111	1.1765	1.2500	1.3333	1.4286
1100	0.9091	0.9569	1.0101	0.0695	1.1364	1.2121	1.2987
1200	0.8333	0.8772	0.9259	0.9804	1.0417	1.1111	1.1905
1300	0.7692	0.8097	0.8547	0.9050	0.9615	1.0256	1.0989

AMPERES IN ALTERNATING CURRENT CIRCUITS

Single-phase Circuits—Continued

Amperes for One Kilowatt at Different Power Factors

	POVER FACTOR IN PER CENT						
Volts	100	95	90	85	80	75	70
1400	0.7143	0.7519	0.7936	0.8403	0.8929	0.9524	1.0204
1500	0.6667	0.7018	0.7407	0.7843	0.8333	0.8889	0.9524
1600	0.6250	0.6579	0.6944	0.7353	0.7812	0.8333	0.8929
1700	0.5882	0.6192	0.6536	0.6921	0.7353	0.7843	0.8403
1800	0.5556	0.5848	0.6173	0.6536	0.6944	0.7407	0.7937
1900	0.5263	0.5540	0.5848	0.6192	0.6579	0.7018	0.7519
2000	0.5000	0.5263	0.5556	0.5882	0.6250	0.6667	0.7143
2100	0.4762	0.5013	0.5291	0.5602	0.5952	0.6349	0.6803
2200	0.4545	0.4785	0.5050	0.5348	0.5682	0.6061	0.6494
2300	0.4348	0.4577	0.4831	0.5115	0.5435	0.5797	0.6211
2400	0.4167	0.4386	0.4630	0.4902	0.5208	0.5556	0.5952
2500	0.4000	0.4210	0.4444	0.4706	0.5000	0.5333	0.5714
3000	0.3333	0.3509	0.3704	0.3922	0.4167	0.4444	0.4761
3300	0.3030	0.3190	0.3367	0.3565	0.3788	0.4040	0.4329
3500	0.2857	0.3007	0.3175	0.3361	0.3571	0.3809	0.4082
4000	0.2500	0.2632	0.2778	0.2941	0.3125	0.3333	0.3571
4500	0.2222	0.2339	0.2469	0.2614	0.2778	0.2963	0.3175
5000	0.2000	0.2105	0.2222	0.2353	0.2500	0.2667	0.2857
6000	0.1667	0.1754	0.1852	0.1961	0.2083	0.2222	0.2381
6600	0.1515	0.1595	0.1684	0.1783	0.1894	0.2020	0.2165
7000	0.1429	0.1504	0.1587	0.1681	0.1786	0.1905	0.2041
8000	0.1250	0.1316	0.1389	0.1471	0.1563	0.1667	0.1786
9000	0.1111	0.1170	0.1234	0.1307	0.1389	0.1481	0.1587
10000	0.1000	0.1053	0.1111	0.1177	0.1250	0.1333	0.1429
11000	0.0909	0.0957	0.1010	0.1070	0.1136	0.1212	0.1299
12000	0.0833	0.0877	0.0926	0.0980	0.1042	0.1111	0.1190
13000	0.0769	0.0810	0.0855	0.0905	0.0962	0.1026	0.1099
14000	0.0714	0.0752	0.0794	0.0840	0.0893	0.0952	0.1020
15000	0.0667	0.0702	0.0741	0.0784	0.0833	0.0889	0.0952
16000	0.0625	0.0658	0.0694	0.0735	0.0781	0.0833	0.0893
17000	0.0588	0.0619	0.0654	0.0692	0.0735	0.0784	0.0840
18000	0.0556	0.0585	0.0617	0.0654	0.0694	0.0741	0.0794
19000	0.0526	0.0554	0.0585	0.0619	0.0658	0.0702	0.0752
20000	0.0500	0.0526	0.0556	0.0588	0.0625	0.0667	0.0714
25000	0.0400	0.0421	0.0444	0.0471	0.0500	0.0533	0.0571
30000	0.0333	0.0351	0.0370	0.0392	0.0417	0.0444	0.0476
35000	0.0286	0.0301	0.0317	0.0336	0.0357	0.0381	0.0408
40000	0.0250	0.0263	0.0278	0.0294	0.0313	0.0333	0.0357
45000	0.0222	0.0234	0.0247	0.0261	0.0278	0.0296	0.0317
50000	0.0200	0.0211	0.0222	0.0235	0.0250	0.0267	0.0286
55000	0.0182	0.0191	0.0202	0.0214	0.0227	0.0242	0.0260
60000	0.0167	0.0175	0.0185	0.0196	0.0208	0.0222	0.0238

AMPERES IN ALTERNATING CURRENT CIRCUITS

Three-phase Circuits

Amperes per Wire for One Kilowatt at Different Power Factors

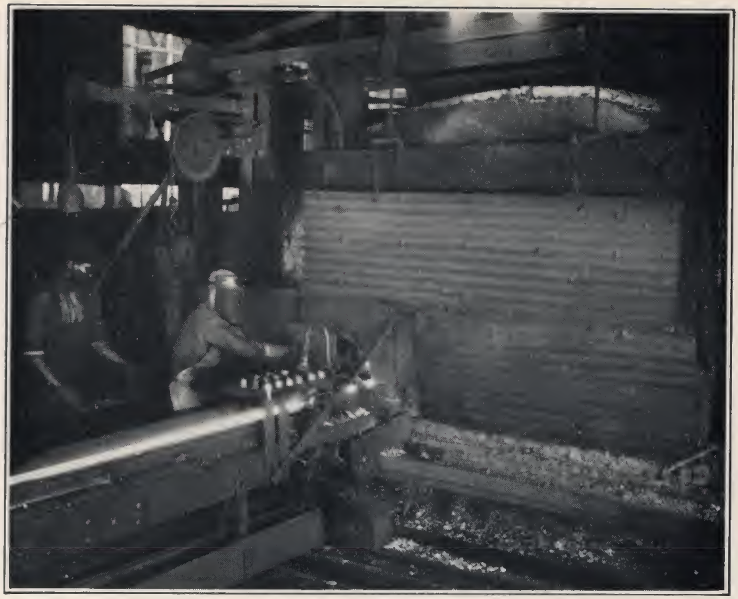
	Power Factor in Per Cent						
Volts	100	95	90	85	80	75	70
100	5.7735	6.0774	6.4150	6.7924	7.2169	7.6980	8.2479
110	5.2486	5.5249	5.8319	6.1749	6.5608	6.9982	7.4980
115	5.0204	5.2847	5.5783	5.9064	6.2756	6.6939	7.1721
120	4.8112	5.0645	5.3458	5.6603	6.0141	6.4150	6.8732
125	4.6188	4.8619	5.1320	5.4339	5.7735	6.1584	6.5983
130	4.4411	4.6749	4.9346	5.2249	5.5514	5.9215	6.3445
140	4.1240	4.3410	4.5821	4.8517	5.1549	5.4986	5.8913
150	3.8490	4.0516	4.2767	4.5283	4.8112	5.1320	5.4986
160	3.6084	3.7984	4.0094	4.2453	4.5105	4.8112	5.1549
170	3.3962	3.5749	3.7735	3.9955	4.2453	4.5282	4.8517
180	3.2075	3.3763	3.5639	3.7735	4.0094	4.2767	4.5821
190	3.0387	3.1986	3.3763	3.5749	3.7984	4.0516	4.3410
200	2.8867	3.0387	3.2075	3.3962	3.6084	3.8490	4.1239
210	2.7493	2.8940	3.0548	3.2345	3.4366	3.6657	3.9276
220	2.6243	2.7624	2.9159	3.0874	3.2804	3.4992	3.7490
225	2.5660	2.7010	2.8511	3.0188	3.2075	3.4213	3.6657
230	2.5102	2.6423	2.7891	2.9532	3.1378	3.3470	3.5860
240	2.4056	2.5322	2.6729	2.8301	3.0070	3.2075	3.4366
250	2.3094	2.4310	2.5660	2.7170	2.8867	3.0792	3.2992
300	1.9245	2.0258	2.1384	2.2642	2.4056	2.5660	2.7493
330	1.7495	1.8416	1.9439	2.0583	2.1869	2.3327	2.4960
350	1.6496	1.7364	1.8328	1.9406	2.0620	2.1994	2.3566
400	1.4434	1.5194	1.6038	1.6981	1.8042	1.9245	2.0620
440	1.3122	1.3812	1.4579	1.5437	1.6402	1.7495	1.8745
450	1.2830	1.3505	1.4256	1.5094	1.6037	1.7107	1.8329
500	1.1547	1.2155	1.2830	1.3585	1.4434	1.5396	1.6496
550	1.0497	1.1050	1.1664	1.2350	1.3121	1.3996	1.4996
600	.9622	1.0129	1.0692	1.1321	1.2028	1.2830	1.3746
700	.8248	.8682	.9164	.9703	1.0310	1.0997	1.1783
800	.7217	.7597	.8019	.8491	.9021	.9623	1.0310
900	.6415	.6753	.7128	.7547	.8019	.8553	.9164
1000	.5774	.6077	.6415	.6792	.7217	.7698	.8248
1100	.5249	.5525	.5832	.6175	.6561	.6998	.7498
1200	.4811	.5064	.5346	.5660	.6014	.6413	.6873
1300	.4441	.4675	.4935	.5225	.5551	.5922	.6344

AMPERES IN ALTERNATING CURRENT CIRCUITS

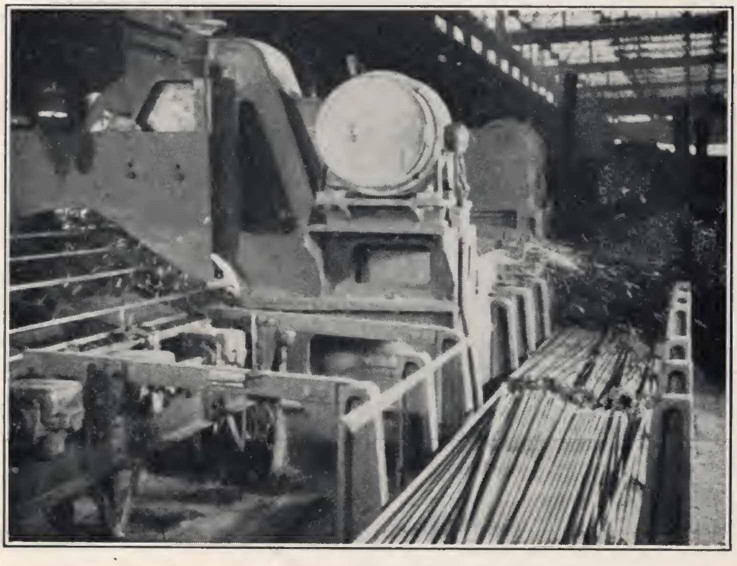
Three-phase Circuits—Continued

Amperes for One Kilowatt at Different Power Factors

	Power Factor in Per Cent						
Volts	100	95	90	85	80	75	70
1400	.4124	.4341	.4582	.4852	.5155	.5499	.5891
1500	.3849	.4052	.4277	.4528	.4811	.5132	.5499
1600	.3608	.3798	.4009	.4245	.4511	.4811	.5155
1700	.3396	.3575	.3774	.3996	.4245	.4528	.4852
1800	.3207	.3376	.3564	.3773	.4009	.4277	.4582
1900	.3039	.3199	.3376	.3575	.3798	.4052	.4341
2000	.2807	.3039	.3207	.3396	.3608	.3849	.4124
2100	.2749	.2894	.3055	.3234	.3437	.3666	.3928
2200	.2624	.2762	.2916	.3087	.3280	.3499	.3749
2300	.2510	.2642	.2789	.2953	.3138	.3347	.3586
2400	.2406	.2532	.2673	.2830	.3007	.3208	.3437
2500	.2309	.2431	.2566	.2717	.2887	.3079	.3299
3000	.1924	.2026	.2138	.2264	.2406	.2566	.2749
3300	.1749	.1842	.1944	.2058	.2187	.2333	.2499
3500	.1650	.1736	.1833	.1941	.2062	.2199	.2357
4000	.1443	.1519	.1604	.1698	.1804	.1924	.2062
4500	.1283	.1350	.1426	.1509	.1604	.1711	.1833
5000	.1155	.1216	.1283	.1358	.1443	.1540	.1650
6000	.0962	.1013	.1069	.1132	.1203	.1283	.1375
6600	.0875	.0921	.0972	.1029	.1093	.1167	.1249
7000	.0825	.0868	.0916	.0970	.1031	.1100	.1178
8000	.0722	.0760	.0802	.0849	.0902	.0962	.1031
9000	.0641	.0675	.0713	.0755	.0802	.0855	.0916
10000	.0577	.0608	.0642	.0679	.0722	.0770	.0825
11000	.0525	.0552	.0583	.0617	.0656	.0700	.0750
12000	.0481	.0506	.0535	.0566	.0601	.0642	.0687
13000	.0444	.0467	.0493	.0522	.0555	.0592	.0634
14000	.0412	.0434	.0458	.0485	.0515	.0550	.0589
15000	.0385	.0405	.0428	.0453	.0481	.0513	.0550
16000	.0361	.0380	.0401	.0425	.0451	.0481	.0515
17000	.0340	.0357	.0377	.0399	.0425	.0453	.0485
18000	.0321	.0338	.0356	.0377	.0401	.0428	.0458
19000	.0304	.0320	.0338	.0357	.0380	.0405	.0434
20000	.0289	.0304	.0321	.0340	.0361	.0385	.0412
25000	.0231	.0243	.0257	.0272	.0289	.0308	.0330
30000	.0192	.0203	.0214	.0226	.0241	.0257	.0275
33000	.0175	.0184	.0194	.0206	.0219	.0233	.0250
35000	.0165	.0174	.0183	.0194	.0206	.0220	.0236
40000	.0144	.0152	.0160	.0170	.0180	.0192	.0206
45000	.0128	.0135	.0143	.0151	.0160	.0171	.0183
50000	.0115	.0122	.0128	.0136	.0144	.0154	.0165
55000	.0105	.0111	.0117	.0124	.0131	.0140	.0150
60000	.0096	.0101	.0107	.0113	.0120	.0128	.0137



Welding Butt-Weld Pipe used in the manufacture of conduit 3″ and smaller



Tandem Hot Saws cutting random length pipe in two exact lengths for Conduit

Wire sizes in these tables apply to entire branch circuit when motor is rated at 2 h.p. or less. Running overload protection not required with motors rated at 2 h.p. or less, but recommended with all continuous duty motors larger than ½ h.p.

Conduit sizes given for three No. 12 and for three No. 8 wires are based on assumption that single-conductor, single-braid, solid wire will be used; otherwise, next larger size conduit must be used.

3-Phase, 220-Volt, Squirrel Cage, Induction Motors—Continuous Duty

		Wire and Conduit Sizes					
		To Running Overload Protection Rubber or Varnished Cloth Insulation		From Running Overload Protection to Motor Rubber Insulation			
Rated Horse Power	Approx. Full Load Current	Wire	Conduit	Wire	Conduit	Circuit Overload Protection	Motor Running Over load Protection
¼	1	14	½	..		10	..
½	2	14	½	..	..	10	..
¾	2.5	14	½	..	..	12	..
1	3	14	½	..	..	15	..
1½	4.5	14	½	..	..	20	..
2	6	14	½	..	..	25	..
3	9	12	½	14	½	30	12
5	14	10	¾	12	½	40	20
7½	20	8	¾	10	¾	50	25
10	26	6	1¼	8	¾	65	35
15	38	6	1¼	6	1¼	90	50
20	51	4	1¼	4	1¼	120	65
25	63	3	1¼	3	1¼	130	80
30	75	1	1½	1	1½	150	100
35	88	0	2	0	2	180	110
40	101	0	2	0	2	200	125
50	123	000	2	00	2	250	150
60	146	0000	2½	000	2	300	180
75	182	250000	2½	0000	2½	375	225
100	245	350000	3	350000	3	500	300

MOTOR TABLES—Continued

3-Phase, 440-Volt, Squirrel Cage, Induction Motors—Continuous Duty

		Wire and Conduit Sizes					
		To Running Overload Protection Rubber or Varnished Cloth Insulation		From Running Overload Protection to Motor Rubber Insulation			
Rated Horse Power	Approx. Full Load Current	Wire	Conduit	Wire	Conduit	Circuit Overload Protection	Motor Running Overload Protection
¼	.5	14	½	..	..	5	..
½	1	14	½	..	..	5	..
¾	1.3	14	½	..	..	8	..
1	1.6	14	½	..	..	10	..
1½	2.3	14	½	..	..	12	..
2	3	14	½	..	..	15	..
3	4.6	14	½	14	½	20	6
5	7	14	½	14	½	25	10
7½	10	12	½	14	½	30	12
10	13	10	¾	12	½	35	20
15	19	8	¾	10	¾	50	25
20	26	6	1¼	8	¾	65	35
25	32	6	1¼	6	1¼	75	40
30	38	6	1¼	6	1¼	90	50
35	44	4	1¼	4	1¼	100	55
40	51	4	1¼	4	1¼	120	65
50	62	3	1¼	3	1¼	130	80
60	73	1	1½	2	1½	150	90
75	91	0	2	0	2	200	110
100	123	000	2	00	2	250	150
125	156	0000	2½	0000	2½	325	200
150	184	250000	2½	0000	2½	375	225
200	246	350000	3	350000	3	500	300
250	310	500000	3	500000	3	600	400

MOTOR TABLES

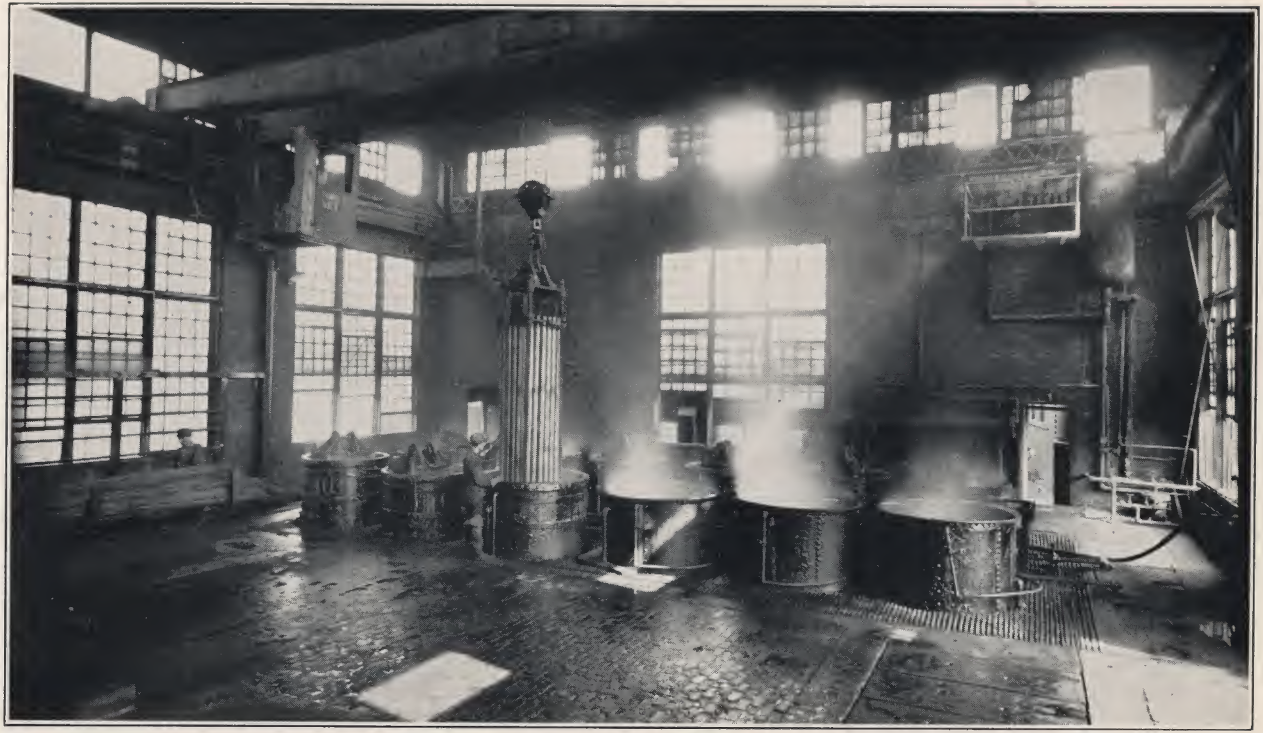
Speeds given are for 60 cycles. Table applies to 50 cycle motors with corresponding speeds of 1500 and 100 r. p. m. Wire sizes given in this table apply to entire branch circuit when motor is rated at 2 H. P. or less. Running overload protection not required with motors rated at 2 H. P. or less, but recommended with all continuous duty motors larger than ½ H. P. Assumed that no starting rheostat will be used.

Single-Phase, 110-Volt Repulsion-Induction Motors with Compensating Windings—Continuous Duty

			Wire and Conduit Sizes					
			To Running Overload Protection Rubber or Varnished Cloth Insulation		From Running Overload Protection to Motor Rubber Insulation			
Rated Horse Power	Syn. Speed	Approx. Full Load Current	Wire	Conduit	Wire	Conduit	Circuit Overload Protection	Motor Running Overload Protection
¼	1800	4	14	½	..	..	15	..
¼	1200	5.8	14	½	..	..	20	..
½	1800	6.4	14	½	..	..	20	..
½	1200	7.4	14	½	..	..	20	..
¾	1800	8.6	14	½	..	..	25	..
¾	1200	10.6	12	½	..	..	30	..
1	1800	11	12	½	..	..	30	..
1	1200	13.6	10	¾	..	..	35	..
1½	1800	15	10	¾	..	..	35	..
2	1800	20.6	8	¾	..	..	45	..
2	1200	23.4	8	¾	..	..	45	..
3	1800	28.4	6	1	8	¾	55	35
3	1200	31	6	1	6	1	60	40
5	1800	46	4	1¼	4	1¼	90	60
5	1200	48	4	1¼	4	1¼	100	60

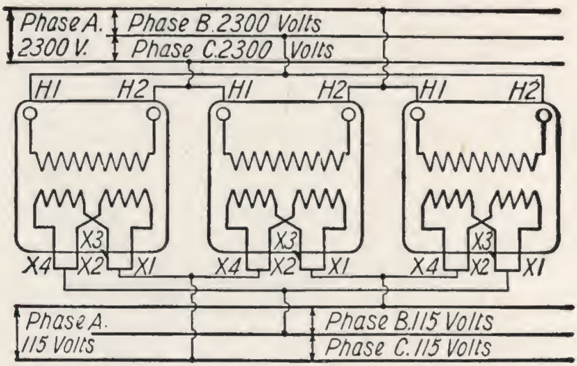
Single-Phase, 220-Volt Repulsion-Induction Motors with Compensating Windings—Continuous Duty

¼	1800	2	14	½	..	..	10	..
¼	1200	2.9	14	½	..	..	10	..
½	1800	3.2	14	½	..	..	10	..
½	1200	3.7	14	½	..	..	15	..
¾	1800	4.3	14	½	..	..	15	..
¾	1200	5.3	14	½	..	..	15	..
1	1800	5.5	14	½	..	..	20	..
1	1200	6.8	14	½	..	..	20	..
1½	1800	7.5	14	½	..	..	20	..
2	1800	10.3	12	½	..	..	30	..
2	1200	11.7	12	½	..	..	30	..
3	1800	14.2	10	¾	12	½	35	20
3	1200	15.5	10	¾	12	½	35	20
5	1800	23	8	¾	8	¾	45	30
5	1200	24	8	1	8	¾	45	30
7½	1800	33	6	1	6	1	65	40
7½	1200	38	4	1¼	6	1	75	50
10	1800	45	4	1¼	4	1¼	90	55
10	1200	47	4	1¼	4	1¼	90	60



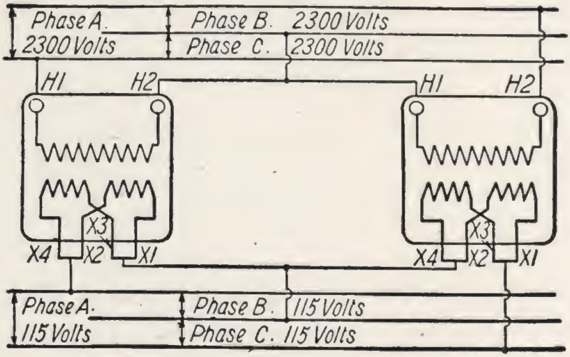
Pickling Department Preparing Pipe for Enameling or Galvanizing

No. 1



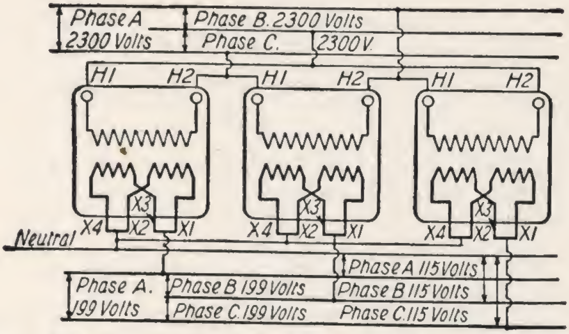
Three phase 3 wire "Closed Delta" primary to three phase 3 wire "Closed Delta" secondary.

No. 2



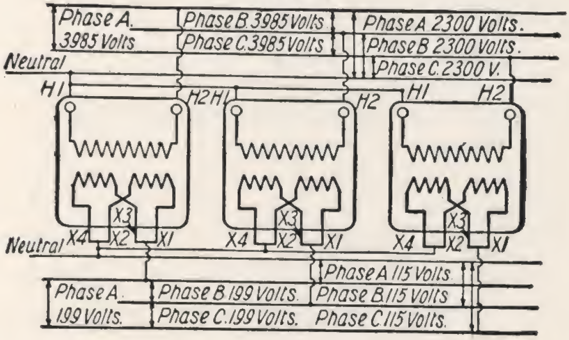
Three phase 3 wire "Open Delta" primary to three phase 3 wire "Open Delta" secondary. "Open Delta" connection, as shown, will deliver only 87 per cent of rated capacity and may cause line disturbances due to unbalancing Only recommended in cases of emergency.

No. 3



Three phase 3 wire "Closed Delta" primary to 3 phase 4 wire "Star" secondary.

No. 4



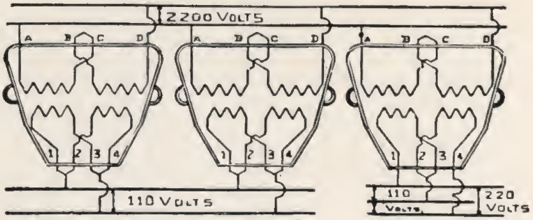
Three phase 4 wire "Star" primary to three phase 4 wire "Star" secondary.

Note.—Connections shown are for 2300 volts primaries, with secondaries arranged for 20 to 1 ratio. To change secondaries for 230 volts or 10 to 1 ratio, connect ×2 and ×3 together (in series) in each transformer, first disconnecting ×2 and ×3 from ×1 and ×4.

TRANSFORMER CONNECTIONS

Continued

No. 5



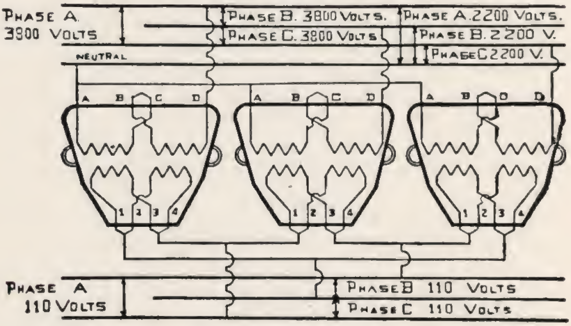
Single-phase 2-wire primary to single-phase 2-wire and also 3-wire secondary.

See note.

Two-phase 4-wire primary to two-phase 4-wire secondary. Connect transformers, one on each phase as per diagram Fig. 5.

See note.

No. 6



Three-phase 4-wire "Star" primary to three phase 3-wire "Closed Delta" secondary.

See note.

TRANSFORMER CONNECTIONS

Continued

No. 7

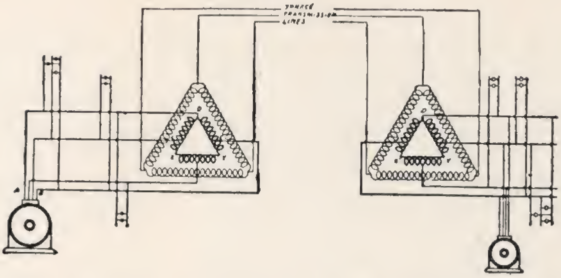


Diagram showing connections of Pittsburgh method of transformation, three-phase 3-wire to two-phase 4-wire and three-phase 3-wire. Transformers are here connected in "Closed Delta," using three single-phase units.

No. 8

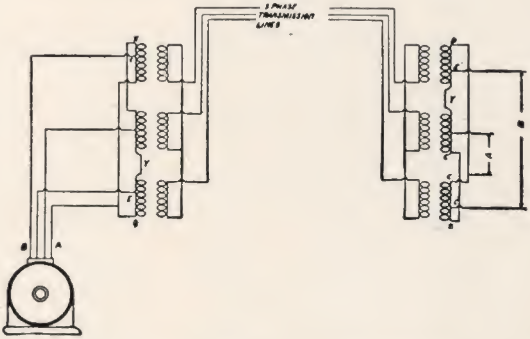


Diagram showing connections of Pittsburgh method of transformation, three-phase 3-wire to two-phase 4-wire. Transformers are here connected in "Star," using three single-phase units.

Transformer Capacity for Motors

In selecting proper size transformers for motors for either 1, 2 or three-phase 1-KVA transformer capacity should be allowed for each motor horse power.

Note.—Connections shown are for 2200 volts primaties, with secondaries arranged for 20 to 1 ratio. To change secondaries for 220 volts or 10 to 1 ratio, connect 2 and 3 together (in series) in each transformer, first disconnecting 2 and 3 from 1 and 4. To change primaries from 2200 volts line as shown to 1100 volts line, disconnect B and C, and connect B to A and C to D in each transformer.

DIAMETERS OF CIRCULAR MIL CABLES

National Electrical Code Standard

Rubber Covered

Area Circular Mils	No. of Wires	Approximate Size, Inches			
		Each Wire	Rubber Wall	Diam. Rubber	Diam. Over All
2000000	127	.1255	.125	1.882	1.982
			.188	2.008	2.108
1500000	91	.1284	.125	1.663	1.763
			.188	1.789	1.889
1250000	91	.1172	.125	1.540	1.640
			.188	1.666	1.766
1000000	61	.128	.125	1.402	1.502
			.188	1.528	1.628
950000	61	.1248	.125	1.374	1.474
			.188	1.500	1.600
900000	61	.1215	.125	1.344	1.444
			.188	1.470	1.570
850000	61	.118	.125	1.312	1.412
			.188	1.438	1.538
800000	61	.1145	.125	1.281	1.381
			.188	1.407	1.507
750000	61	.1109	.125	1.248	1.348
			.188	1.374	1.474
700000	61	.1071	.125	1.214	1.314
			.188	1.340	1.440
650000	61	.1032	.125	1.180	1.280
			.188	1.306	1.406

DIAMETERS OF CIRCULAR MIL CABLES

National Electrical Code Standard

Rubber Covered

Area Circular Mils	No. of Wires	Approximate Size, Inches			
		Each Wire	Rubber Wall	Diam. Rubber	Diam. Over All
600000	61	.0992	.125	1.143	1.243
			.188	1.269	1.369
550000	61	.095	.110	1.075	1.175
			.156	1.167	1.267
500000	61	.0905	.100	1.015	1.115
			.125	1.065	1.165
450000	61	.0859	.100	.972	1.072
			.125	1.022	1.122
400000	37	.104	.100	.930	1.030
			.125	.980	1.080
375000	37	.1007	.100	.905	1.005
			.125	.955	1.055
350000	37	.0973	.100	.881	.981
			.125	.931	1.031
325000	37	.0937	.100	.856	.956
			.125	.906	1.006
300000	37	.0900	.100	.830	.930
			.125	.880	.980
275000	37	.0862	.100	.805	.905
			.125	.855	.955
250000	37	.0822	.100	.77	.876
			.125	.826	.926

DIAMETERS OF CIRCULAR MIL CABLES

National Electrical Code Standard

Lead Encased

Area Circular Mils	No. of Wires	Approximate Size, Inches				
		Each Wire	Rubber Wall	Diam. Over Rubber	Lead Wall	Diam. Over All
2000000	127	.1255	.125	1.882	⅛	2.235
			.188	2.008	⅛	2.360
1500000	91	.1284	.125	1.663	⅛	2.015
			.188	1.789	⅛	2.140
1250000	91	.1172	.125	1.540	1/10	1.840
			.125	1.540	⅛	1.890
			.188	1.666	1/10	1.970
			.188	1.666	⅛	2.020
1000000	61	.128	.125	1.420	1/10	1.700
			.125	1.420	⅛	1.755
			.188	1.528	1/10	1.830
			.188	1.528	⅛	1.880
950000	61	1248	.125	1.374	1/10	1.675
			.125	1.374	⅛	1.725
			.188	1.500	1/10	1.800
			.188	1.500	⅛	1.850
900000	61	.1215	.125	1.344	1/10	1.645
			.125	1.344	⅛	1.695
			.188	1.470	1/10	1.770
			.188	1.470	⅛	1.820
850000	61	.118	.125	1.312	3/32	1.600
			.188	1.438	1/10	1.740
			.188	1.438	⅛	1.790
800000	61	.1145	.125	1.281	3/32	1.570
			.188	1.407	1/10	1.710
			.188	1.407	⅛	1.760
750000	61	.1109	.125	1.248	3/32	1.535
			.188	1.374	1/10	1.675
			.188	1.374	⅛	1.725

DIAMETERS OF CIRCULAR MIL CABLES

National Electrical Code Standard
Lead Encased

Area Circular Mils	No. of Wires	Approximate Size, Inches				
		Each Wire	Rubber Wall	Diam. Over Rubber	Lead Wall	Diam. Over All
700000	61	.1071	.125	1.214	3/32	1.500
			.188	1.340	1/10	1.640
			.188	1.340	⅛	1.690
650000	61	.1032	.125	1.180	3/32	1.470
			.188	1.306	3/32	1.595
600000	61	.0992	.125	1.143	3/32	1.430
			.188	1.269	3/32	1.560
550000	61	.095	.110	1.075	3/32	1.365
			.156	1.167	3/32	1.457
500000	61	.0905	.100	1.015	3/32	1.305
			.125	1.065	3/32	1.355
450000	61	.0859	.100	.972	3/32	1.260
			.125	1.022	3/32	1.310
400000	37	.104	.100	.930	3/32	1.220
			.125	.980	3/32	1.270
375000	37	.1007	.100	.905	3/32	1.195
			.125	.955	3/32	1.245
350000	37	.0973	.100	.881	3/32	1.170
			.125	.931	3/32	1.220
325000	37	.0937	.100	.856	3/32	1.145
			.125	.906	3/32	1.195
300000	37	.0900	.100	.830	3/32	1.120
			.125	.880	3/32	1.170
275000	37	.0862	.100	.805	3/32	1.095
			.125	.855	3/32	1.145
250000	37	.0822	.100	.776	3/32	1.065
			.125	.826	3/32	1.115

DIAMETER OF RUBBER COVERED WIRES

Solid						Stranded		
Rubber Wall Inches	Diam. over Rubber Inches	Diam. Over All Inches	Size B. & S. Gauge	Area Circular Mils	Conductor A-B. & S. B-B. W. G.	Rubber Wall Inches	Diam. over Rubber Inches	Diam. Over All Inches
.100	.660	.710	0000	197260	19x10A	.100	.709	.759
.130	.720	.770				.130	.769	.819
.160	.780	.830				.160	.829	.879
.100	.610	.660	000	156400	19x11A	.100	.654	.704
.130	.670	.720				.130	.714	.764
.160	.730	.780				.160	.774	.824
.100	.565	.615	00	124000	19x12A	.100	.604	.654
.130	.625	.675				.130	.664	.714
.160	.685	.735				.160	.724	.774
.100	.525	.575	0	98500	19x15B	.100	.560	.610
.130	.585	.635				.130	.620	.670
.160	.645	.695				.160	.680	.730
.080	.449	.500	1	80300	19x16B	.080	.485	.535
.110	.509	.559				.110	.545	.595
.140	.569	.619				.140	.605	.655
.080	.418	.468	2	63900	19x17B	.080	.450	.500
.110	.478	.528				.110	.510	.560
.140	.538	.588				.140	.570	.620

The first dimensions given on each size are N. E. C. standard. The other dimensions are actual sizes of commercial wires.

DIAMETER OF RUBBER COVERED WIRES—Continued

Solid						Stranded		
Rubber Wall Inches	Diam. Over Rubber Inches	Diam. Over All Inches	Size B. & S. Gauge	Area Circular Mils	Conductor A-B & S. B-B. W.G.	Rubber Wall Inches	Diam. Over Rubber Inches	Diam. Over All Inches
.070	.369	.419	3	57600	7x11A	.070	.412	.462
.100	.429	.479				.100	.472	.522
.130	.489	.539				.130	.532	.582
.070	.344	.394	4	45700	7x12A	.070	.382	.432
.100	.404	.454				.100	.442	.492
.130	.464	.514				.130	.502	.552
.070	.322	.372	5	36300	7x15B	.070	.356	.406
.100	.382	.432				.100	.416	.466
.130	.442	.492				.130	.476	.526
.070	.302	.352	6	28700	7x14A	.070	.332	.382
.100	.362	.412				.100	.392	.442
.130	.422	.472				.130	.452	.502
.070	.284	.324	7	22800	7x15A	.070	.311	.351
.100	.344	.384				.100	.371	.411
.130	.404	.444				.130	.431	.471
.050	.228	.268	8	16800	7x18B	.050	.247	.287
.080	.288	.328				.080	.307	.347
.110	.348	.388				.110	.367	.407

The first dimensions given on each size are N. E. C. standard. The other dimensions are actual sizes of commercial wires.

DIAMETER OF RUBBER COVERED WIRES—Continued

Solid						Stranded		
Rubber Wall Inches	Diam. Over Rubber Inches	Diam. Over All Inches	Size B. & S. Gauge	Area Circular Mils	Conductor A-B & S. B-B. W.G.	Rubber Wall Inches	Diam. Over Rubber Inches	Diam. Over All Inches
.050	.202	.242	10	11400	7x18A	.050	.220	.260
.080	.262	.302				.080	.280	.320
.110	.322	.362				.110	.340	.380
.050	.180	.220	12	7150	7x20A	.050	.195	.235
.069	.219	.259				.080	.255	.295
.100	.280	.320				.110	.315	.355
.050	.165	.205	14	4375	7x23B	.050	.175	.215
.061	.188	.228				.080	.235	.275
.100	.265	.305				.110	.295	.335
.037	.125	.165	16	2830	7x24A	.037	.134	.174
.053	.156	.196				.067	.194	.234
.069	.188	.228				.097	.254	.294
.037	.115	.150	18	1780	7x26A	.037	.122	.157
.043	.125	.160				.067	.182	.217
.058	.156	.190				.097	.242	.277

The first dimensions given on each size are N. E. C. standard. The other dimensions are actual sizes of commercial wires.

DIAMETER LEAD ENCASED CABLE

Solid Wires

Size B. & S. Gauge	Rubber Wall	Diam. Over Rubber	Lead Wall	Diam. Over All
0000	.100	.660	$\frac{5}{64}$	.866
	.130	.720	$\frac{5}{64}$	.926
	.160	.780	$\frac{5}{64}$	.986
000	.100	.610	$\frac{5}{64}$	.816
	.130	.670	$\frac{5}{64}$	.876
	.160	.730	$\frac{5}{64}$	.936
00	.100	.565	$\frac{5}{64}$	.771
	.130	.625	$\frac{5}{64}$	.831
	.160	.685	$\frac{5}{64}$	.891
0	.100	.525	$\frac{5}{64}$	.731
	.130	.585	$\frac{5}{64}$	.791
	.160	.645	$\frac{5}{64}$	.851
1	.080	.449	$\frac{5}{64}$	.656
	.110	.509	$\frac{5}{64}$	.716
	.140	.569	$\frac{5}{64}$	.776
2	.080	.418	$\frac{1}{16}$	.593
	.110	.478	$\frac{1}{16}$	.653
	.140	.538	$\frac{1}{16}$	.713

Stranded Cables

Size B. & S. Gauge	Area Circular Mils	Conductor A-B. & S. B-B. W. G.	Rubber Wall	Diam. Over Rubber	Lead Wall	Diam. Over All
0000	197,260	19x10A	.100	.709	$\frac{5}{64}$	.915
			.130	.769	$\frac{5}{64}$	.975
			.160	.829	$\frac{5}{64}$	1.035
000	156,400	19x11A	.100	.654	$\frac{5}{64}$	.860
			.130	.714	$\frac{5}{64}$	.920
			.160	.774	$\frac{5}{64}$	.980
00	124,000	19x12A	.100	.604	$\frac{5}{64}$	.810
			.130	.664	$\frac{5}{64}$	.870
			.160	.724	$\frac{5}{64}$	.930
0	98,500	19x15B	.100	.560	$\frac{5}{64}$	.766
			.130	.620	$\frac{5}{64}$	.826
			.160	.680	$\frac{5}{64}$	.886
1	80,300	19x16B	.080	.485	$\frac{5}{64}$	.691
			.110	.545	$\frac{5}{64}$	.751
			.140	.605	$\frac{5}{64}$	.811

The first dimensions given on each size are for National Electrical Code 600 volt cable.

DIAMETER LEAD ENCASED CABLE—Continued

Solid Wires					Stranded Wires						
Size B. & S. Gauge	Rubber Wall	Diam. Over Rubber	Lead Wall	Diam. Over All	Size B. & S. Gauge	Circular Area Mils	Conductor A-B & S. B-B. W.G.	Rubber Wall	Diam. Over Rubber	Lead Wall	Diam. Over All
3	.070	.369	$\frac{1}{16}$	.544							
	.100	.429	$\frac{1}{16}$	.604							
	.130	.489	$\frac{1}{16}$	.664	2	63,900	19x17B	.080	.450	$\frac{5}{64}$	.656
4	.070	.344	$\frac{1}{16}$	.519				.110	.510	$\frac{5}{64}$	.716
	.100	.404	$\frac{1}{16}$	.579				.140	.570	$\frac{5}{64}$	.776
	.130	.464	$\frac{1}{16}$	.639							
5	.070	.322	$\frac{1}{16}$	.497	3	57,600	7x11A	.070	.412	$\frac{1}{16}$	.587
	.100	.382	$\frac{1}{16}$	.557				.100	.472	$\frac{5}{64}$	.678
	.130	.442	$\frac{1}{16}$	.617				.130	.532	$\frac{5}{64}$	.738
6	.070	.302	$\frac{1}{16}$	.477							
	.100	.362	$\frac{1}{16}$	.537	4	45,700	7x12A	.070	.382	$\frac{1}{16}$	.557
	.130	.422	$\frac{1}{16}$	.597				.100	.442	$\frac{1}{16}$	.617
7	.070	.284	$\frac{3}{64}$	.418				.130	.502	$\frac{5}{64}$	.708
	.100	.344	$\frac{1}{16}$	.509							
	.130	.404	$\frac{1}{16}$	.569	5	36,300	7x15B	.070	.356	$\frac{1}{16}$	.531
8	.050	.228	$\frac{3}{64}$	.362				.100	.416	$\frac{1}{16}$	.591
	.080	.288	$\frac{3}{64}$	.422				.130	.476	$\frac{5}{64}$	.682
	.110	.348	$\frac{3}{64}$	.482							

The first dimensions given on each size are for National Electrical Code 600 volt cable.

DIAMETER LEAD ENCASED CABLE—Continued

Solid Wires

Size B. & S. Gauge	Rubber Wall	Diam. Over Rubber	Lead Wall	Diam.
10	.050	.202	$\frac{3}{64}$	.335
	.080	.262	$\frac{3}{64}$	.395
	.110	.322	$\frac{3}{64}$	.455
12	.050	.180	$\frac{3}{64}$	.327
	.069	.219	$\frac{3}{64}$	.353
	.100	.280	$\frac{3}{64}$	.415
14	.050	.165	$\frac{3}{64}$	.300
	.061	.188	$\frac{3}{64}$	.322
	.100	.265	$\frac{3}{64}$	.400
16	.037	.125	$\frac{3}{64}$	.259
	.053	.156	$\frac{3}{64}$	.290
	.069	.188	$\frac{3}{64}$	.322
18	.037	.115	$\frac{3}{64}$	.244
	.043	.125	$\frac{3}{64}$	.254
	.058	.156	$\frac{3}{64}$	.284

Stranded Wires

Size B. & S. Gauge	Area Circular Mils	Conductor A-B & S. B-B. W.G.	Rubber Wall	Diam. Over Rubber	Lead Wall	Diam. Over All
6	28,700	7x14A	.070	.332	$\frac{1}{16}$	.507
			.100	.392	$\frac{1}{16}$	.567
			.130	.452	$\frac{3}{64}$	.658
8	16,800	7x18B	.050	.247	$\frac{3}{64}$	.381
			.080	.307	$\frac{3}{64}$	.441
			.110	.367	$\frac{1}{16}$	.532
10	11,400	7x18A	.050	.220	$\frac{3}{64}$	.355
			.080	.280	$\frac{3}{64}$	.415
			.110	.340	$\frac{1}{16}$	.505
12	7,150	7x20A	.050	.195	$\frac{3}{64}$	.330
			.080	.255	$\frac{3}{64}$	.390
			.110	.315	$\frac{3}{64}$	.450

The first dimensions given on each size are for National Electrical Code 600 volt cable.

WIRE DATA

Standard Stranded Copper Conductors

Size C. M.	Number of Wires In The Strand								
	7	19	37	7x7—49	61	91	127	169	217
	Diameter In Inches of Each Wire In The Strand								
2000000	.5345	.3243	.2325	.202	.181	.1482	.1255*	.1088	.096
1750000	.5000	.3034	.2175	.189	.1694	.1386	.1157*	.1003	.0898
1500000	.4629	.2810	.2013	.175	.1568	.1284*	.1087	.0942	.0831
1250000	.4226	.2565	.1838	.1507	.1431	.1172	.0992	.086	.0759
1000000	.378	.2294	.1644	.1429	.1285*	.1048	.0887	.0769	.0678
950000	.3684	.2236	.1602	.1392	.1248*	.1021	.0864	.075	.0662
900000	.3586	.2176	.1559	.1355	.1215*	.0994	.0841	.073	.0644
850000	.3484	.2115	.1516	.1317	.1181*	.0966	.0818	.0709	.0626
800000	.338	.205	.147	.1278	.1145*	.0937	.0793	.0687	.0607
750000	.3273	.1986	.1424	.1237	.1109*	.0908	.0768	.0666	.0588
700000	.3163	.1919	.1375	.1195	.1071*	.0883	.0742	.0644	.0568
650000	.3047	.1850	.1325	.1152	.1032*	.0845	.0716	.0620	.0547
600000	.2928	.1778	.1273	.1107	.0992*	.0812	.0687	.0596	.0526
550000	.2803	.1701	.1219	.106	.0950*	.0777	.0658	.0570	.0503
500000	.2672	.1622	.1162*	.101	.0905	.0741	.0627	.0544	.048
450000	.2535	.1539	.1103*	.0958	.0859	.0703	.0595	.0516	.0455
400000	.2391	.1451	.1040*	.0904	.081	.0663	.0561	.0487	.0429
350000	.2236	.1357	.0973*	.0845	.0757	.0620	.0526	.0455	.0401
300000	.207	.1257	.0901*	.0783	.0701	.0573	.0486	.0421	.0372
250000	.189	.1147	.0822*	.0714	.064	.0524	.0444	.0384	.0340

WIRE DATA—Continued

Standard Stranded Copper Conductors

	Number of Wires In The Strand								
Size	7	19	37	7x7—49	61	91	127	169	217
Size B.&S.									
0000	.1736	.1055*	.0756	.0657	.0589	.0482	.0408	....	....
000	.1548	.0940*	.0673	.0586	.0525	.0429	.0363	....	....
00	.1378	.0836*	.0599	.0521	.0467	.0382	.0323	....	....
0	.1228	.0746*	.0534	.0464	.0416	.0340	.0288	....	....
1	.1093	.0663*	.0475	.0413	.0370	.0303	.0252	....	....
2	.0973*	.0592	.0423	.0369	.0329	.0269	.0228	....	....
3	.0867*	.0526	.0377	.0327	.0294	.0240	.0203	....	....
4	.0772*	.0468	.0335	.0291	.0261	.0214	.0179	....	....
5	.0687*	.0417	.0299	.026	.0233	.0190	.0161	....	....
6	.0612*	.0372	.0266	.0231	.0207	.0169	.0143	....	....
7	.0545*	.0331	.0237	....	.0184	.0151	.0128	....	....
8	.0485*	.0293	.0211	.0184	.0164	.0135	.0114	....	....
9	.0435*	.0262	.0187	....	.0146	.0120	.0101	....	....
10	.0385*	.0223	.0168	....	.0129	.0106	.0090	....	....

*Indicates standard construction for rubber covered cables.

WEATHERPROOF COPPER WIRES

Solid Conductors

	Triple-Braid Weatherproof Wire			Slow-Burning Weatherproof Wire			Slow-Burning Wire		
Size B.&S.	Wt.Per 1000 Ft. Lbs.	Wt.Per Mile Lbs.	Diam. Over All In.	Wt.Per 1000 Ft. Lbs.	Wt.Per Mile Lbs.	Diam. Over All In.	Wt.Per 1000 Ft. Lbs.	Wt.Per Mile Lbs.	Diam. Over All In.
0000	767	4050	25/32	862	4550	¾	925	4890	¾
000	630	3220	47/64	710	3750	45/64	760	4020	45/64
00	502	2650	39/64	562	2970	37/64	600	3170	37/64
0	407	2150	9/16	462	2440	17/32	495	2610	17/32
1	316	1670	½	340	1800	15/32	365	1930	15/32
2	260	1370	15/32	280	1480	7/16	320	1690	7/16
3	200	1050	27/64	230	1220	13/32	270	1425	13/32
4	164	865	25/64	190	1000	⅜	220	1160	⅜
5	134	710	11/32	155	820	11/32	190	1000	11/32
6	112	590	5/16	127	670	5/16	160	845	5/16
8	75	395	17/64	85	450	7/64	100	530	17/64
10	53	280	¼	60	315	¼	80	420	¼
12	35	185	7/32	42	220	7/32	55	290	7/32
14	25	130	3/16	30	160	3/16	40	210	3/16
16	14	75	5/32	15	80	5/32	18	95	5/32
18	11	58	⅛	12	63	⅛	14	75	⅛

WEATHERPROOF COPPER WIRES

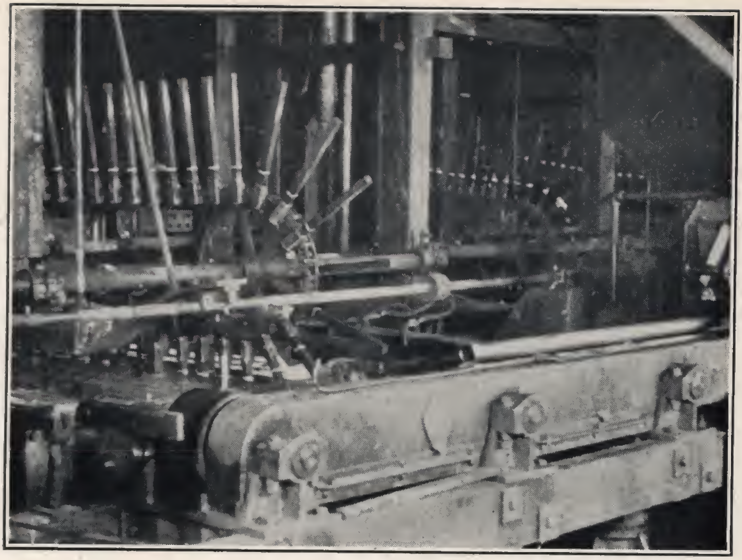
Stranded Conductors

Size C. M.	Triple-Braid Weatherproof Wire			Slow-Burning Weatherproof Wire			Slow-Burning Wire		
	Wt. Per 1000 Ft. Lbs.	Wt. Per Mile Lbs.	Diam. Over All In.	Wt. Per 1000 Ft. Lbs.	Wt. Per Mile Lbs.	Diam. Over All In.	Wt. Per 1000 Ft. Lbs.	Wt. Per Mile Lbs.	Diam. Over All In.
2000000	7000	37000	2	7300	38500	2 7/8	7800	41000	2
1750000	6200	32750	2	6550	34600	1 7/8	6900	36300	1 7/8
1500000	5400	28500	1 7/8	5675	30000	1 3/4	6000	31300	1 3/4
1250000	4500	23800	1 3/4	4780	25200	1 11/16	5000	26400	1 11/16
1000000	3675	19400	1 21/32	3860	10400	1 39/64	3980	21000	1 39/64
900000	3330	17600	1 39/64	3520	18600	1 9/16	3640	19200	1 9/16
800000	3000	15800	1 9/16	3180	16800	1 33/64	3280	17300	1 33/64
700000	2650	14000	1 15/32	2820	14900	1 27/64	2920	15400	1 27/64
600000	2235	11800	1 21/64	2350	24000	1 9/32	2460	13000	1 9/32
500000	1900	10000	1 1/4	1990	10500	1 13/64	2080	11000	1 13/64
450000	1725	9100	1 3/16	1820	9600	1 9/64	1900	10000	1 9/64
400000	1550	8200	1 9/64	1650	8700	1 3/32	1700	9000	1 3/32
350000	1345	7100	1	1440	7600	1 1/32	1500	7900	31/32
300000	1175	6200	31/32	1270	6700	15/16	1310	6900	15/16
250000	985	5200	29/32	1060	5600	7/8	1120	5900	7/8
B.&S.									
0000	800	4220	55/64	900	4750	53/64	940	5070	53/64
000	653	3450	51/64	735	3880	49/64	785	4150	49/64
00	522	2760	43/64	583	3080	41/64	625	3300	41/64
0	424	2240	39/64	480	2530	37/64	510	2700	37/64
1	328	1735	35/64	355	1870	33/64	380	2000	33/64
2	270	1425	33/64	290	1540	31/64	335	1770	31/64
3	206	1090	15/32	240	1270	29/64	280	1480	29/64
4	170	900	7/16	195	1030	27/64	230	1220	27/64
5	140	740	3/8	160	845	3/8	195	1030	3/8
6	115	610	11/32	132	695	11/32	165	870	11/32
8	78	410	9/32	87	460	9/32	105	555	9/32

WEATHERPROOF COPPER WIRES

Solid Conductors

No. B.&S.	Diameter		Square of Sectional Diameter=Area		Approved Carrying Capacity In Amperes National Code	Approximate			
						Weight Lbs., Bare		Weatherproof Insulation	
	Mils	Mili-meters	Circular Mils	Square Milimeters		Lbs. Per 1000 Ft.	Lbs. Per Mile	Lbs. Per 1000 Ft.	Lbs. Per Mile
0000	460.	11.684	211600.	107.219	225	639.8	3378.	767	4050
000	409.640	10.405	167805.	85.028	175	507.3	2678.	629	3320
00	364.800	9.266	133079.4	67.431	150	402.4	2124.	502	2650
0	324.950	8.254	105592.5	53.504	125	319.4	1686.	407	2150
1	289.300	7.348	83694.2	42.409	100	253.0	1336.	316	1670
2	257.630	6.544	66373.	33.632	90	200.6	1059.	260	1370
3	229.420	5.827	52634.	26.670	80	159.1	840.1	199	1050
4	204.310	5.189	41742.	21.151	70	126.2	666.3	164	865
5	181.940	4.621	33102.	16.773	55	100.0	528.2	135	710
6	162.020	4.115	26250.5	13.301	50	79.35	419.0	112	590
8	128.490	3.264	16509.	8.366	35	49.92	263.6	75	395
10	101.890	2.588	10381.	5.260	25	31.30	165.8	53	280
12	80.808	2.053	6529.9	3.309	20	19.74	104.2	35	185
14	64.084	1.628	4106.8	2.081	15	12.42	65.59	25	130
16	50.820	1.291	2582.9	1.309	6	7.802	41.20	20	105



Charging End of Galvanizing Unit

Discharging End of Galvanizing Unit
Showing Galvanized Conduit on Drying Tables

FINE MAGNET WIRE

Size B.&S.	Diam. In.	Ohms Per Pound Single Cotton	Ohms Per Pound Double Cotton	Feet Per Pound Single Cotton	Feet Per Pound Double Cotton	Size B.&S.	Diam. In.	Ohms Per Pound Single Cotton	Ohms Per Pound Double Cotton	Feet Per Pound Single Cotton	Feet Per Pound Double Cotton
20	.0319	3.15	3.02	311	298	31	.0089	461.0	384.5	3483	2768
21	.0284	4.97	4.72	389	370	32	.0079	717.0	585.0	4414	3737
22	.0253	7.87	7.44	491	461	33	.0070	1115.0	880.0	5688	4697
23	.0225	12.45	11.7	624	584	34	.0063	1715.0	1315.0	6400	6168
24	.0201	19.65	18.25	778	745	35	.0056	2640.0	1960.0	8393	6737
25	.0179	30.9	28.45	958	903	36	.0050	4070.0	2890.0	9846	7877
26	.0159	48.5	44.3	1188	1118	37	.0044	6180.0	4230.0	11636	9309
27	.0142	76.5	68.8	1533	1422	38	.0039	9430.0	6150.0	13848	10666
28	.0126	120.0	106.5	1903	1759	39	.0035	14200.0	8850.0	18286	11907
29	.0112	190.5	164.0	2461	2207	40	.0031	21300.0	12500.0	24381	14222
30	.0100	294.5	252.0	2893	2534	....	....	....	....	....	....

MOTOR DUTY RATINGS
By
THE ELECTRIC POWER CLUB

Approximate Percentage of Full Load Current on First Point	Light Starting—15 Seconds to Four Minutes	Heavy Starting—30 Seconds to Four Minutes	Light Intermittent Duty—One to Four Minutes	Heavy Intermittent Duty—Two to Four Minutes	Continuous
25	No. 11	No. 31	No. 51	No. 71	No. 91
50	No. 12	No. 32	No. 52	No. 72	No. 92
70	No. 13	No. 33	No. 53	No. 73	No. 93
100	No. 14	No. 34	No. 54	No. 74	No. 94
150	No. 15	No. 35	No. 55	No. 75	No. 95
200 or More	No. 16	No. 36	No. 56	No. 76	No. 96

Equivalents of Wires

Showing Approximately Equal Capacities in the Use of Conductors of Different Sizes

Total Capacity C. M.	Equivalent In Number of Smaller Conductors or Combinations						
	2	3	4	5	6	Combinations	
1000000	....	....	....	0000	000	....	....
800000	....	....	0000	000	00	....	....
600000	....	0000	000	00	0	....	....
500000	....	000	00	0	1	....	....
400000	0000	00	0	1	2	....	....
350000	000	....	1	2	......	0000 & 00	....
300000	....	0	2	....	3	000 & 00	0000 & 1
250000	00	1	....	3	4	000 & 1	0000 & 4
B.&S.							
0000	0	2	3	4	5	00 & 1	000 & 3
000	1	3	4	5	6	0 & 2	00 & 5
00	2	4	5	6	......	1 & 3	0 & 6
0	3	5	6	....	8	2 & 4	....
1	4	6	....	8	......	3 & 5	....
2	5	....	8	....	......	4 & 6	....
3	6	8	....	10	......	....	....
4	....	....	10	....	......	6 & 8	....
5	8	10	....	12	......	....	....
6	....	....	12	....	14	8 & 10	....
8	....	....	14	....	16	10 & 12	....
10	....	....	16	....	18	12 & 14	....

Formulæ for Determining Amperes, Horse-Power, Kilowatts, and Kilovolt-Amperes

		Alternating Current		
	Direct Current	Single-Phase	*4-Wire 2-Phase	3-Phase
To Find—Amperes When Horse-Power is Known	$\frac{\text{H. P.x746}}{\text{Ex\% Eff.}}$	$\frac{\text{H.P.x746}}{\text{Ex.\%Eff.xp.f.}}$	$\frac{\text{H.P.x746}}{\text{2xEx\%Eff.xp.f.}}$	$\frac{\text{H.P.x746}}{\text{1.73xEx\%Eff.xp.f.}}$
To Find—Amperes When Kilowatts are Known	$\frac{\text{Kw.x1000}}{\text{E}}$	$\frac{\text{Kw.x1000}}{\text{Exp.f.}}$	$\frac{\text{Kw.x1000}}{\text{2xExp.f.}}$	$\frac{\text{Kw.x1000}}{\text{1.73xExp.f.}}$
To Find—Amperes When Kv-a are Known	....	$\frac{\text{Kv-ax1000}}{\text{E}}$	$\frac{\text{Kv-ax1000}}{\text{2xE}}$	$\frac{\text{Kv-ax1000}}{\text{1.73xE}}$
To Find—Kilowatts	$\frac{\text{IxE}}{1000}$	$\frac{\text{IxExp.f.}}{1000}$	$\frac{\text{IxEx2xp.f.}}{1000}$	$\frac{\text{IxEx1.73xp.f.}}{1000}$
To Find—Kv-a	....	$\frac{\text{IxE}}{1000}$	$\frac{\text{IxEx2}}{1000}$	$\frac{\text{IxEx1.73}}{1000}$
To Find—Horse-Power (Output)	$\frac{\text{IxEx\%Eff.}}{746}$	$\frac{\text{IxEx\%Eff.xp.f.}}{746}$	$\frac{\text{IxEx2x\%Eff.xp.f.}}{746}$	$\frac{\text{IxEx1.73x\%Eff.xp.f.}}{746}$

I=Amperes; E=Volts; %Eff.=percent Efficiency; p.f.=Power Factor; Kw=Kilowatts; Kv-a=Kilovolt-amperes; H.P.=Horse Power.

*For 3-wire 2-phase circuits, the current in the common conductor is 1.41 times that in either of the other two conductors.

Putting on Thread Protectors Prior to Enameling

ALUMINUM FOR ELECTRICAL CONDUCTORS

In comparing copper and aluminum, the following properties of these metals should be noted.

	Specific Gravity	Relative Specific Gravity	Conductivity	Tensile Strength Per Square Inch
Copper	8.93	3.33	96 to 99	30000 to 65000 lbs.
Aluminum	2.68	1.	54 to 63	24000 to 55000 lbs.

Conductivity

Pure aluminum has a conductivity of about 63% of that possessed by equally pure copper; commercial aluminum in bars or wire has a conductivity of about 61% of copper; assuming a conductivity of 97% for commercial copper; hence the cross section of conductors of aluminum and copper must be in the inverse ratio of their conductivity. To determine the equivalent of a No. 00 B.&S. gauge copper wire in aluminum wire:61:97:: 133100: 211650 or approximately a No. 0000: or establishing a ratio as follows: 61:97:: 100: 159; it will be found as an approximate rule that for equal conductivity the size of aluminum wire will be about two B. & S. gauge numbers larger than copper wire.

Weight

The comparative weights of equal volumes of copper and aluminum are: Copper, 3.33, aluminum, 1; the comparative weights for equal conductivity will be 100 x 3.33: 159 x 1:: 100: 47.74; or for equal lengths of same conductivity, aluminum weights about 47.74% of copper.

Tensile Strength and Conductivity

The tensile strength is increased and the conductivity decreased by the alloying of aluminum with other metals; for busbars and other large conductors installed with frequent supports, the commercially pure aluminum is used; where subject to strains the alloyed aluminum is recommended; assuming a tensile strength of 39000 pounds square inch, the addition of 1% alloy gives a tensile strength of 45000 pounds and a conductivity of 58%; the addition of 2% alloy gives a tensile strength of 55000 pounds and a conductivity of 54%; aluminum is furnished in the percentages of alloys above noted or with intermediate percentage.

Aluminum For Telephone Wires

The comparatively small amount of current carried on telephone wires makes the use of aluminum quite desirable for this purpose. The following table gives data for aluminum wires of varying conductivity.

Resistance and Tensile Strength of Aluminum Telephone Wire

			62 Per Cent Conductivity		58 Per Cent Conductivity		54 Per Cent Conductivity	
No. in B. & S. Gauge	Area in Sq. Inches	Diameter Mils	Resistance Per 1000 Ft. 75 °F	Tensile Strength Based on 39,000 Lbs. Per Sq. Inch	Resistance Per 1000 Ft. 75 °F	Tensile Strength Based on 45,000 Lbs. Per Sq. Inch	Resistance Per 1000 Ft. 75 °F	Tensile Strength Based on 55,000 Lbs. Per Sq. Inch
4	.03278	204.3	.4012	1278	.4288	1475	.4605	1802
5	.02600	181.9	.5058	1014	.5408	1170	.5818	1430
6	.02062	162.	.638	804	.6820	928	.7325	1133
7	.01635	144.3	.8044	637	.8600	735	.9235	899
8	.01297	128.5	1.034	506	1.105	583	1.187	713
9	.01028	114.4	1.278	401	1.367	462	1.468	565
10	.008155	101.9	1.613	318	1.724	367	1.852	488
11	.006467	90.7	2.033	252	2.173	291	2.335	355
12	.005129	80.8	2.565	200	2.741	231	3.084	282

STRANDED ALUMINUM WIRE
62 Per Cent Conductivity

No. B &S. Gauge	Circular Mils	Diam., Inches Standard Wire	Weight In Pounds Per 1000 Ft., Bare	Weight In Pounds Per 1000 Ft. T.B.W.P.	Weight In Pounds Per 1000 Ft. D.B.W.P.	Resis., Ohms Per 1000 Ft. 75°F.
....	1000000	1.152	920.	1408	......	.01675
....	950000	1.125	874.	1340	......	.01763
....	900000	1.092	828.	1270	......	.01861
....	850000	1.062	782.	1202	......	.01969
....	800000	1.035	736.	1135	......	.02092
....	750000	.999	690.	1067	......	.02232
....	700000	.963	644.	1001	......	.02392
....	650000	.927	598.	938	......	.02575
....	600000	.891	552.	878	......	.02789
....	550000	.855	506.	806	......	.03044
....	500000	.819	460.	740	......	.03347
....	450000	.770	414.	665	......	.03720
....	400000	.728	368.	567	......	.04184
....	350000	.679	322.	502	......	.04782
....	300000	.630	276.	436	......	.0558
....	250000	.590	230.	375	......	.06698
0000	211600	.530	195.	280	266	.07912
000	167805	.470	155.	232	218	.09958
00	133079	.420	123.	192	169	.12563
0	105534	.375	97.	155	127	.1584
1	83694	.330	77.	132	103	.2004
2	66373	.291	61.	108	90	.2515
3	52634	.261	48.5	88	74	.3182
4	41742	.231	38.5	72	62	.4012
5 Solid	33102	.181	30.17	63	55	.5226
6 Solid	26250	.162	23.93	56	45	.6591
8 Solid	16509	.128	15.05	37	35	1.068

COMPARATIVE RESISTANCES

Comparative resistances of various materials taking copper as 1.

To find the resistance of any wire, first get the resistance of the same length and size of copper wire, then multiply this by figure below for the wire used.

Copper	1	Advance	.28	Phosphor-Bronze	3.
Norway Iron	7	S. B.	.32	Platinum	5.5
Soft Steel	8	Climax	.50	Iron Wire (E.B.B.)	5.5
18 Per Cent German Silver	18	Silver	.98	Iron Wire (BB)	6.4
30 Per Cent German Silver	28	Aluminum	1.8	Iron Wire (Special)	7.4

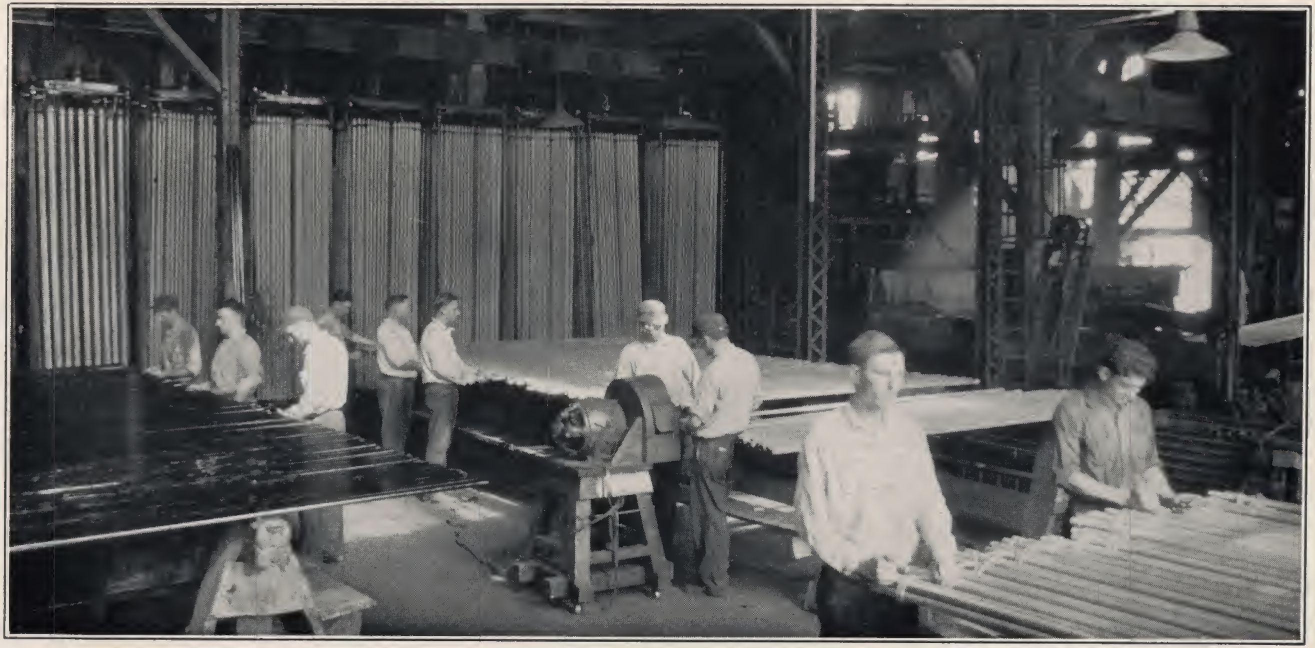
18 Per Cent German Silver

Resistance per mil foot, 189 Ohms.
Temperature co-efficient .00017 per degree Fahr.

No. B. & S.	Ohms 1000 Ft.	No. B. & S.	Ohms 1000 Ft.	No. B. & S.	Ohms 1000 Ft.
0	1.7	14	46.1	28	1192
1	2.2	15	58.2	29	1480
2	2.8	16	72.7	30	1890
3	3.6	17	93.4	31	2386
4	4.5	18	118.	32	2950
5	5.7	19	146.	33	3740
6	7.2	20	184.	34	4760
7	9.1	21	234.	35	6020
8	11.5	22	295.	36	7560
9	14.5	23	370.	37	9550
10	18.1	24	468.	38	12038
11	22.8	25	590.	39	15240
12	28.8	26	749.	40	19285
13	36.5	27	936.	—	—

Tensile Strength of Copper Wire

Size, Wire	Breaking Wt., Lbs.		Size, Wire	Breaking Wt., Lbs.	
B. & S.	Hand-Drawn	Annealed	B. & S.	Hand-Drawn	Annealed
0000	9971	5650	9	617	349
000	7907	4480	10	489	277
00	6271	3553	11	388	219
0	4973	2818	12	307	174
1	3943	2234	13	244	138
2	3127	1772	14	193	109
3	2480	1405	15	153	87
4	1967	1114	16	133	69
5	1559	883	17	97	55
6	1237	700	18	77	43
7	980	555	19	61	34
8	778	440	20	48	27



Partial View of Conduit Finishing Department.

PROPERTIES OF CLIMAX RESISTANCE WIRE

Resistance per mil foot at 75° Fahr.—525 Ohms.
Temperature co-efficient .0004 per degree Fahr.
Specific gravity, 8.137.

No. B. & S.	Diam. In.	Area In Circ. Mils C.M=D2	Resistance per 1000 Ft. at 75 °F.	Wt. Lbs. Per 1000 Ft. Bare	Ohms Per Pound
1	.289	83521.	6.2	231.	.026
2	.258	66564.	7.9	184.	.041
3	.229	52441.	10.	145.	.066
4	.204	41616.	12.6	115.	.105
5	.182	33124.	15.8	92.	.165
6	.162	26244.	20.	73.	.263
7	.144	20736.	25.3	57.	.427
8	.128	16384.	32.	45.	.685
9	.116	12996.	40.4	36.	1.08
10	.102	10404.	50.4	29.	1.65
11	.091	8281.	63.4	23.	2.70
12	.081	6561.	80.	18.	4.27
13	.072	5184.	101.	14.3	6.85
14	.064	4096.	128.	11.3	10.9
15	.057	3249.	161.	9.2	16.9
16	.051	2601.	202.	7.2	27.
17	.045	2025.	258.	5.6	44.5
18	.040	1600.	328.	4.42	71.3
19	.036	1296.	404.	3.58	108.
20	.032	1024.	510.	2.83	174.

No. B. & S.	Diam. In.	Area In Circ. Mils C.M=D2	Resistance per 1000 Ft. at 75 °F.	Wt. Lbs. Per 1000 Ft. Bare	Ohms Per Pound
21	.0285	812.3	646.	2.24	284.
22	.0253	640.1	820.	1.77	456.
23	.0226	510.8	1027.	1.41	720.
24	.0201	404.	1290.	1.12	1142.
25	.0179	320.4	1640.	.89	1810.
26	.0159	252.8	2080.	.70	2920.
27	.0142	201.6	2580.	.56	4570.
28	.0126	158.8	3300.	.44	7400.
29	.0113	127.7	4100.	.35	11560.
30	.010	100.	5250.	.276	18785.
31	.0089	79.2	6620.	.219	29800.
32	.008	64.	8200.	.177	45265.
33	.0071	50.4	10410.	.139	73214.
34	.0063	39.7	13220.	.11	118300.
35	.0056	31.4	16720.	.087	189000.
36	.005	25.	21000.	.069	300000.
37	.0045	20.2	26000.	.056	468000.
38	.004	16.	33000.	.045	733000.
39	.0035	12.2	43000.	.034	1264000.
40	.003	9.	58000.	.025	2320000.

MELTING POINT AND RELATIVE CONDUCTIVITY OF DIFFERENT METALS AND ALLOYS

Metals	Relative Conductivity	Melting Point °F
Pure silver	100.0	1873
Pure copper	100.0	2550
Refined and crystallized copper	99.9	--------
Telegraphic silicious bronze	98.0	--------
Alloy of copper and silver (50%)	86.65	--------
Pure gold	78.0	2016
Silicide of copper, 4% Si.	75.0	--------
Silicide of copper, 12% Si.	54.7	--------
Pure aluminum	54.2	1160
Tin with 12% of sodium	46.9	--------
Telephonic silicious bronze	35.0	--------
Copper with 10% of lead	30.0	--------
Pure Zinc	29.9	773
Telephonic phosphor-bronze	29.0	--------
Silicious brass, 25% zinc	26.4	--------
Brass with 35% zinc	21.59	--------
Phosphor-tin	17.7	--------
Alloy of gold and silver (50%)	16.12	--------
Swedish iron	16.4	4000
Pure Banca Tin	15.5	442
Antimonial copper	12.7	--------
Aluminum bronze (10%)	12.6	--------
Siemens Steel	12.0	--------
Pure platinum	10.6	4100
Copper with 10% of nickel	10.6	--------
Cadmium Amalgam (15%)	10.2	--------
Dronier mercurial bronze	10.14	--------
Arsenical copper (10%)	9.1	--------
Pure lead	8.88	630
Bronze with 20% tin	8.4	--------
Pure nickel	7.89	2800
Phosphor-bronze, 10% tin	6.5	--------
Phospor-copper, 9% phos.	4.9	--------
Antimony	3.88	840

COPPER BUS-BAR DATA

Sizes, Weights and Resistances

Thickness In.	Width In.	Wts. Per Ft. at 3.213 Lbs. Per Cubic Inch	Area In Square In.	Ohms Per Ft. at 8.341 Per Sq. Mil. Ft.	Capacity In Ampere
1/16	½	.1205	.0313	.00026691	30
1/16	¾	.1807	.0469	.00017790	50
1/16	1	.2410	.0625	.00013344	60
1/16	1½	.3615	.0938	.00008897	90
⅛	½	.2410	.0625	.00013344	75
⅛	¾	.3615	.0938	.00008897	90
⅛	1	.4820	.125	.00006672	125
⅛	1½	.7230	.1875	.00004448	200
⅛	2	.9640	.25	.00003336	250
¼	¾	.7230	.1875	.00004448	185
¼	1	.9640	.25	.00003336	250
¼	1¼	1.205	.3125	.00002669	315
¼	1½	1.446	.375	.00002224	375
¼	1¾	1.687	.4375	.00001906	435
¼	2	1.928	.5	.00001668	500
¼	2¼	2.169	.5625	.00001482	565
¼	2½	2.410	.625	.00001334	630
½	¾	1.446	.375	.00002224	370
½	1	1.928	.500	.00001668	500
½	1¼	2.410	.625	.00001334	625
½	1½	2.892	.750	.00001112	750
½	1¾	3.374	.875	.00000953	875
½	2	3.856	1.	.00000834	1000
½	2¼	4.338	1.125	.00000741	1185
½	2½	4.820	1.25	.00006667	1250
½	2¾	5.304	1.375	.00000606	1375
½	3	5.784	1.500	.00000556	1500
½	3½	6.266	1.625	.00000513	1625
½	3½	6.748	1.750	.00000475	1750
½	3¾	7.23	1.875	.00000444	1875
½	4	7.712	2.000	.00000417	2000
¾	1	2.892	.750	.00001112	750
¾	1½	4.338	1.125	.00000741	1125
¾	2	5.784	1.500	.00000556	1500
¾	2½	7.23	1.875	.00000444	1875
¾	3	8.676	2.250	.00000370	2250
¾	3½	10.122	2.625	.00000317	2650
¾	4	11.568	3.000	.0000278	3000

Carrying Capacity is Figured at 1,000 Amperes per Square Inch.

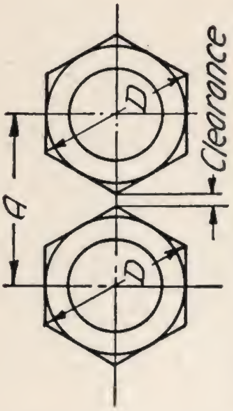
SPACING OF BUS-BARS

Voltage	Distance Between Bus Centers In.	Min. Distance Between Opposite Live Parts In.	Min. Distance Between Live Parts and Ground In.
250	1½- 2½	1 -2	¾-1½
650	2 - 3	1½-2½	1 -2
1100	4 - 5	1½-3½	1½-2½
2200	5 - 6½	2¾-4	2 -2¾
4000	6 - 7½	3 -4½	2¼-3
6600	7 - 8	3½-4½	2½-3
7500	8 - 9	4 -4½	2¾-3¼
9000	9 -10	4¼-4½	3 -3½
11000	9 -11	4½-4¾	3¼-3¾
13200	9 -12	4¾-5	3½-4¼
15000	9 -14	5 -5½	3¾-4½
16500	10 -14	5½-6	4½-5
18000	11 -14	6 -7	5 -6
22000	12 -15	7½-9	6 -7
27000	14 -16	10 -12	8 -9
35000	18 -22	12 -15	10 -12
44000	22 -27	16 -18	13½-15
60000	28 -31	17½-19	16 -17½
66000	34 -38	22 -24	18½-23
75000	36 -42	26 -30	25 -27½
90000	46 -54	32 -35	27 -29
100000	54 -60	34½-39	28½-32
110000	60 -72	38 -41	33 -36
122000	66 -78	42 -47	35½-39
130000	74 -84	48½-56	39 -41
150000	82 -96	59 -67	45 -50
160000	88 -104	70 -84	53 -62

The distances given for the Lower Values are Based on a Safety Factor of 3½ times between Live Parts of Opposite Polarity and Safety Factor three times Between Live Parts and Grounds. The Larger Values Show Good Practice for the Larger Plants or where the Capacities are Liable to be Increased.

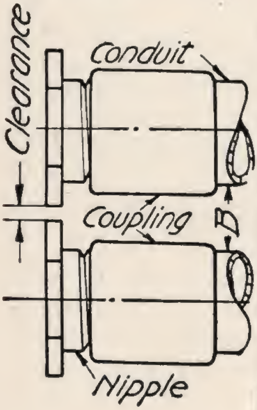
Tubular Buses should be used above 22,000 Volts

APPROXIMATE SPACING OF CONDUIT BUSHINGS AND LOCK NUTS



"D" in simplest Practical Dimension

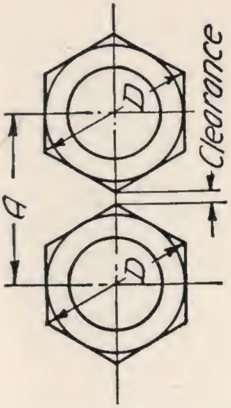
Conduit	"D"
½	1⅛
¾	1⅜
1	1⅝
1¼	2
1½	2¼
2	2⅞
2½	3½
3	4 5/16
3½	4⅞



Size of Conduit		Clearance = ⅛″								
		½″	¾″	1″	1¼″	1½″	2″	2½″	3″	3½″
½″	A	1¼	1⅜	1½	1 11/16	1 13/16	2⅛	2 7/16	2¾	3⅛
	B	.41	.43	.42	.43	.44	.52	.58	.58	.70
¾″	A	1⅜	1½	1⅝	1 13/16	1 15/16	2¼	2 9/16	3	3¼
	B	.43	.45	.44	.46	.46	.54	.60	.60	.72
1″	A	1½	1⅝	1¾	1 15/16	2 1/16	2⅜	2 11/16	3	3⅜
	B	.43	.45	.44	.46	.46	.54	.60	.60	.73
1¼″	A	1 11/16	1 13/16	1 15/16	2⅛	2¼	2 9/16	2⅞	3¼	3 9/16
	B	.43	.46	.46	.46	.47	.55	.62	.67	.74
1½″	A	1 13/16	1 15/16	2 1/16	2¼	2⅜	2 11/16	3	3⅜	3 11/16
	B	.44	.46	.46	.47	.47	.56	.62	.67	.74
2″	A	2⅛	2¼	2⅜	2 9/16	2 11/16	3	3 5/16	3⅝	4
	B	.52	.54	.53	.55	.56	.63	.63	.69	.82
2½″	A	2 7/16	2 9/16	2 11/16	2⅞	3	3 5/16	3⅝	3 15/16	4 5/16
	B	.58	.60	.60	.61	.62	.69	.76	.76	.89
3″	A	2¾	3	3	3¼	3⅜	3⅝	3 15/16	4 7/16	4¾
	B	.58	.60	.60	.67	.67	.69	.74	.94	1.00
3½″	A	3⅛	3¼	3⅜	3 9/16	3 11/16	4	4 5/16	4¾	5
	B	.70	.72	.73	.74	.74	.82	.89	1.00	1.00

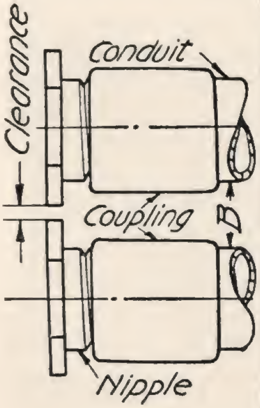
Size of Conduit		Clearance = ¼″								
		½″	¾″	1″	1¼″	1½″	2″	2½″	3″	3½″
½″	A	1⅜	1½	1⅝	1 13/16	1 15/16	2¼	2 9/16	2⅞	3¼
	B	.53	.55	.54	.55	.56	.64	.70	.70	.83
¾″	A	1½	1⅝	1¾	1 15/16	2 1/16	2⅜	2 11/16	3	3⅜
	B	.55	.57	.56	.58	.58	.66	.72	.72	.86
1″	A	1⅝	1¾	1⅞	2 1/16	2 3/16	2½	2 13/16	3⅛	3½
	B	.55	.57	.56	.58	.58	.66	.72	.72	.85
1¼″	A	1 13/16	1 15/16	2 1/16	2¼	2⅜	2 11/16	3	3⅜	3 11/16
	B	.55	.58	.58	.58	.59	.67	.73	.79	.86
1½″	A	1 15/16	2 1/16	2 3/16	2⅜	2½	2 13/16	3⅛	3½	3 13/16
	B	.56	.58	.58	.59	.59	.68	.74	.79	.87
2″	A	2¼	2⅜	2½	2 11/16	2 13/16	3⅛	3 7/16	3¾	4⅛
	B	.64	.66	.65	.67	.68	.75	.81	.81	.94
2½″	A	2 9/16	2 11/16	2 13/16	3	3⅛	3 7/16	3¾	4 1/16	4 7/16
	B	.70	.72	.72	.73	.74	.81	.87	.88	1.00
3″	A	2⅞	3	3⅛	3⅜	3½	3¾	4 1/16	4 9/16	4⅞
	B	.70	.72	.72	.79	.79	.81	.88	1.06	1.12
3½″	A	3¼	3⅜	3½	3 11/16	3 13/16	4⅛	4 7/16	4⅞	5⅛
	B	.83	.86	.85	.86	.87	.94	1.00	1.12	1.12

APPROXIMATE SPACING OF CONDUIT BUSHINGS AND LOCK NUTS



"D" in simplest Practical Dimension

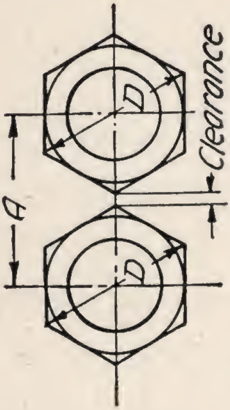
Conduit	"D"
½	1⅛
¾	1⅜
1	1⅝
1¼	2
1½	2¼
2	2⅞
2½	3½
3	4 5/16
3½	4⅞



Size of Conduit		Clearance = ⅜″								
		½″	¾″	1″	1¼″	1½″	2″	2½″	3″	3½″
½″	A	1½	1⅝	1¾	1 15/16	2 1/16	2⅜	2 11/16	3	3⅜
	B	.66	.68	.67	.68	.69	.77	.83	.83	.96
¾″	A	1⅝	1¾	1⅞	2 1/16	2 3/16	2½	2 13/16	3⅛	3½
	B	.68	.70	.69	.71	.71	.79	.85	.85	.98
1″	A	1¾	1⅞	2	2 3/16	2 5/16	2⅝	2 15/16	3¼	3⅝
	B	.68	.69	.69	.71	.71	.78	.85	.85	.98
1¼″	A	1 15/16	2 1/16	2 3/16	2⅜	2½	2 13/16	3⅛	3½	3 13/16
	B	.68	.71	.71	.71	.72	.80	.87	.92	.99
1½″	A	2 1/16	2 3/16	2 5/16	2½	2⅝	2 15/16	3¼	3⅝	3 15/16
	B	.69	.71	.71	.72	.72	.81	.87	.92	.99
2″	A	2⅜	2½	2⅝	2 13/16	2 15/16	3¼	3 7/16	3⅞	4¼
	B	.77	.79	.78	.80	.81	.88	.88	.94	1.07
2½″	A	2 11/16	2 13/16	2 15/16	3⅛	3¼	3 9/16	3⅞	4 3/16	4 7/16
	B	.83	.85	.85	.86	.87	.94	1.01	1.01	1.13
3″	A	3	3⅛	3¼	3½	3⅝	3⅞	4 3/16	4 11/16	5
	B	.83	.85	.85	.92	.92	.94	.99	.99	1.25
3½″	A	3⅜	3½	3⅝	3 13/16	3 15/16	4¼	4 9/16	5	5¼
	B	.96	.98	.98	.99	.99	1.07	1.13	1.25	1.25

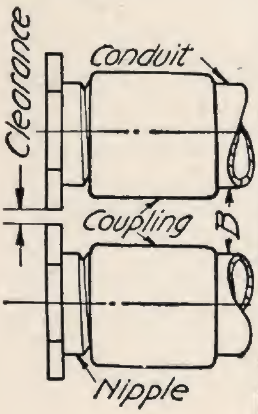
Size of Conduit		Clearance = ½″								
		½″	¾″	1″	1¼″	1½″	2″	2½″	3″	3½″
½″	A	1⅝	1¾	1⅞	2 1/16	2 3/16	2½	2 13/16	3⅛	3½
	B	.78	.80	.79	.80	.81	.89	.95	.95	1.08
¾″	A	1¾	1⅞	2	2 3/16	2 5/16	2⅝	2 15/16	3¼	3⅝
	B	.80	.82	.81	.83	.83	.91	.97	.97	1.10
1″	A	1⅞	2	2⅛	2 5/16	2 7/16	2¾	3 1/16	3⅜	3¾
	B	.80	.81	.81	.83	.83	.90	.97	.97	1.10
1¼″	A	2 1/16	2 3/16	2 5/16	2½	2⅝	2 15/16	3¼	3⅝	3 15/16
	B	.80	.83	.83	.83	.84	.92	.99	1.04	1.11
1½″	A	2 3/16	2 5/16	2 7/16	2⅝	2¾	3 1/16	3⅜	3¾	4 1/16
	B	.81	.83	.83	.84	.84	.93	.98	1.04	1.11
2″	A	2½	2⅝	2¾	2 15/16	3 1/16	3⅜	3 11/16	4	4⅜
	B	.89	.91	.90	.92	.93	1.00	1.00	1.06	1.20
2½″	A	2 13/16	2 15/16	3 1/16	3¼	3⅜	3 11/16	4	4 5/16	4 11/16
	B	.95	.97	.97	.98	.99	1.06	1.13	1.13	1.26
3″	A	3⅛	3¼	3⅜	3⅝	3¾	4	4 5/16	4 13/16	5⅛
	B	.95	.97	.97	1.04	1.04	1.06	1.14	1.14	1.31
3½″	A	3½	3⅝	3¾	3 15/16	4 1/16	4⅛	4 11/16	5 1/16	5⅜
	B	1.01	1.04	1.03	1.04	1.11	1.13	1.31	1.31	1.37

APPROXIMATE SPACING OF CONDUIT BUSHINGS AND LOCK NUTS



"D" in simplest Practical Dimension

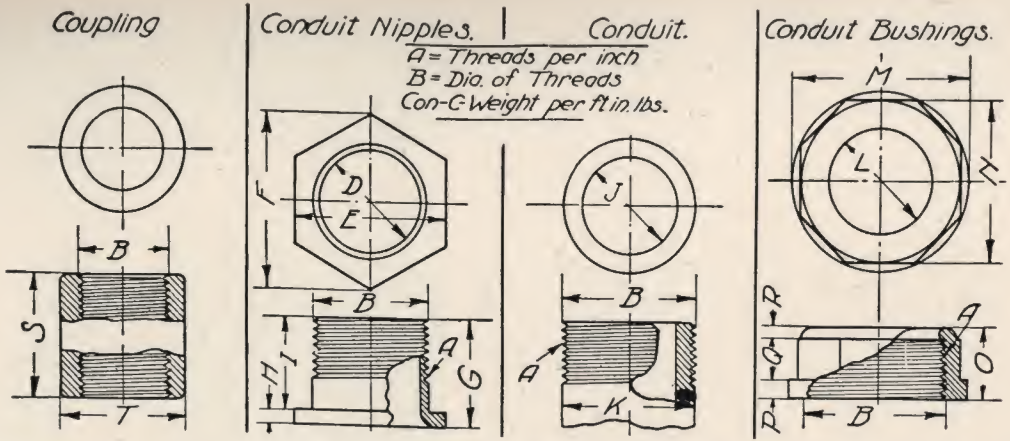
Conduit	"D"
½	1⅛
¾	1⅜
1	1⅝
1¼	2
1½	2¼
2	2⅞
2½	3½
3	4 5/16
3½	4⅞



Size of Conduit		Clearance = ⅝"								
		½"	¾"	1"	1¼"	1½"	2"	2½"	3"	3½"
½"	A	1¾	1⅞	2	2 3/16	2 5/16	2⅝	2 15/16	3¼	3⅝
	B	.91	.93	.92	.93	.94	1.02	1.08	1.08	1.14
¾"	A	1⅞	2	2⅛	2 5/16	2 7/16	2¾	3 1/16	3⅜	3¾
	B	.93	.95	.94	.96	.96	1.04	1.10	1.10	1.17
1"	A	2	2⅛	2¼	2 7/16	2 9/16	2⅞	3 3/16	3½	3⅞
	B	.92	.94	.94	.96	.96	1.03	1.10	1.10	1.16
1¼"	A	2 3/16	2 5/16	2 7/16	2⅝	2¾	3 1/16	3⅜	3¾	4 1/16
	B	.93	.96	.96	.96	.97	1.05	1.12	1.17	1.24
1½"	A	2 5/16	2 7/16	2 9/16	2¾	2⅞	3 3/16	3½	4	4 3/16
	B	.94	.96	.96	.97	.97	1.06	1.11	1.17	1.24
2"	A	2⅝	2¾	2⅞	3 1/16	3 3/16	3½	3 13/16	4¼	4½
	B	1.02	1.04	1.03	1.05	1.06	1.13	1.13	1.19	1.32
2½"	A	2 15/16	3 1/16	3 3/16	3⅜	3½	3 13/16	4⅛	4½	4 13/16
	B	1.08	1.10	1.10	1.11	1.12	1.19	1.26	1.26	1.39
3"	A	3¼	3⅜	3½	3¾	4	4¼	4½	4 15/16	5¼
	B	1.08	1.10	1.10	1.17	1.17	1.19	1.24	1.24	1.44
3½"	A	3⅝	3¾	3⅞	4 1/16	4 3/16	4¼	4 13/16	5¼	5½
	B	1.14	1.17	1.16	1.24	1.24	1.32	1.39	1.44	1.56

Size of Conduit		Clearance = ¾"								
		½"	¾"	1"	1¼"	1½"	2"	2½"	3"	3½"
½"	A	1⅞	2	2⅛	2 5/16	2 7/16	2¾	3 1/16	3⅜	3¾
	B	1.03	1.05	1.04	1.05	1.06	1.14	1.20	1.20	1.26
¾"	A	2	2⅛	2¼	2 7/16	2 9/16	2⅞	3 3/16	3½	3⅞
	B	1.05	1.07	1.06	1.08	1.08	1.16	1.22	1.22	1.29
1"	A	2⅛	2¼	2⅜	2 9/16	2 11/16	3	3 5/16	3⅝	4
	B	1.04	1.06	1.06	1.08	1.08	1.15	1.22	1.22	1.35
1¼"	A	2 5/16	2 7/16	2 9/16	2¾	2⅞	3 3/16	3½	3⅞	4 3/16
	B	1.05	1.08	1.08	1.08	1.09	1.17	1.24	1.29	1.30
1½"	A	2 7/16	2 9/16	2 11/16	2⅞	3	3 5/16	3⅝	4⅛	4 5/16
	B	1.06	1.08	1.08	1.09	1.09	1.18	1.25	1.29	1.37
2"	A	2¾	2⅞	3	3 3/16	3 5/16	3⅝	3 15/16	4⅜	4⅝
	B	1.14	1.16	1.15	1.17	1.18	1.25	1.25	1.31	1.45
2½"	A	3 1/16	3 3/16	3 5/16	3½	3⅝	3 13/16	4¼	4⅝	4 15/16
	B	1.20	1.22	1.22	1.23	1.24	1.31	1.38	1.38	1.51
3"	A	3⅜	3½	3⅝	3⅞	4⅛	4⅜	4⅝	5 1/16	5⅜
	B	1.20	1.22	1.22	1.29	1.29	1.31	1.45	1.36	1.56
3½"	A	3¾	3⅞	4	4 3/16	4 5/16	4⅜	4 15/16	5⅜	5⅝
	B	1.26	1.29	1.28	1.36	1.37	1.45	1.51	1.56	1.68

APPROXIMATE SIZES OF CONDUITS, COUPLINGS, NIPPLES AND BUSHINGS



Size of Conduit	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
½″	14.0	.82	.85	.62	1.00	1.15	.62	.12	.50	.62	.84	.62	1.00	.94	.37	.12	.19	.06	1.37	1.12
¾″	14.0	1.02	1.12	.82	1.25	1.44	.81	.19	.62	.82	1.05	.75	1.25	1.12	.44	.12	.25	.06	1.56	1.31
1	11.5	1.28	1.67	1.04	1.37	1.59	.94	.25	.69	1.04	1.31	1.00	1.50	1.37	.50	.16	.25	.09	1.75	1.62
1¼″	11.5	1.63	2.24	1.38	1.75	2.02	1.06	.25	.81	1.38	1.66	1.25	1.81	1.75	.56	.19	.28	.09	2.12	2.00
1½″	11.5	1.87	2.68	1.61	2.00	2.31	1.12	.31	.81	1.61	1.90	1.50	2.12	2.00	.56	.19	.28	.09	2.50	2.25
2″	11.5	2.34	3.61	2.06	2.50	2.89	1.31	.31	1.00	2.06	2.37	1.94	2.56	2.37	.62	.19	.31	.12	2.62	2.75
2½″	8.0	2.82	5.74	2.46	3.00	3.46	1.44	.37	1.06	2.46	2.87	2.37	3.06	2.87	.75	.25	.37	.12	2.87	3.31
3″	8.0	3.44	7.54	3.06	3.75	4.33	1.50	.37	1.12	3.06	3.50	2.87	3.75	3.50	.81	.25	.37	.19	3.06	3.93
3½″	8.0	3.94	9.00	3.54	4.25	4.91	1.62	.44	1.19	3.54	4.00	3.25	4.25	4.00	1.00	.37	.44	.19	3.62	4.43

CURRENT REQUIRED TO FUSE WIRES,

COPPER, GERMAN SILVER AND IRON

B. & S. Gauge	Copper, Amperes	German Silver Amperes	Iron, Amperes
10	333.0	169.0	101.0
11	284.0	146.0	86.0
12	235.0	120.7	71.2
13	200.0	102.6	63.0
14	166.0	85.2	50.2
15	139.0	71.2	42.1
16	117.0	60.0	35.5
17	99.0	50.4	32.6
18	82.8	42.5	25.1
19	66.7	43.2	20.2
20	58.3	29.9	17.7
21	49.3	25.3	14.9
22	41.2	21.1	12.5
23	34.5	17.7	10.9
24	28.9	14.8	8.76
25	24.6	12.6	7.46
26	20.6	10.6	6.22
27	17.7	9.1	5.36
28	14.7	7.5	4.45
29	12.5	6.41	3.79
30	10.25	5.26	3.11
31	8.75	4.49	2.65
32	7.26	3.73	2.2
33	6.19	3.18	1.88
34	5.12	2.64	1.55
35	4.37	3.24	1.33
36	3.62	1.86	1.09
37	3.08	1.58	.93
38	2.55	1.31	.77
39	2.20	1.13	.67
40	1.86	.95	.56

CONDUCTIVITIES

Metal	At 0° C. At 32° F.	At 100° C. At 212° F.
Silver	100.0	71.56
Copper, Hard	99.95	70.27
Gold, Hard	77.96	55.90
Zinc, Pressed	29.02	20.67
Cadmium	23.72	16.77
Platinum, Soft	18.00	———
Iron, Soft	16.80	———
Tin	12.36	8.67
Lead	8.32	5.86
Arsenic	4.76	3.33
Antimony	4.62	3.26
Mercury, Pure	1.60	———
Bismuth	1.245	0.878

The Conductance of a piece of any Metal 1 Cm. Long and 1 Sq. Cm. in Cross-Section is called its Specific Conductance or Conductivity. Conductance is the Reciprocal of Resistance, and Conductivity is the Reciprocal of Resistivity. If the Resistance of 2 Cm. of a piece of any Metal having a Uniform Cross Sectional Area of 1 Sq. Cm. is 4 ohms, its Resistivity is 2 ohms, Conductance ¼ Mho (Ohm Spelled Backwards) and its Conductivity ½ Mho. Percentage Conductivity of a Substance is the Ratio of its Conductivity to that of the Standard at the same Temperature. The Conductivity of Matthiessen's Pure Copper at 0° C. is usually taken as the Standard, 100 per cent.

Inspecting Youngstown Buckeye Conduit

PULLEYS AND GEARS

For single reduction or increase of speed by means of belting where the speed at which each shaft should run is known, and one pulley is in place:

Multiply the diameter of the pulley which you have by the number of revolutions per minute that its shaft makes; divide this product by the speed in revolutions per minute at which the second shaft should run The result is the diameter of pulley to use.

Where both shafts with pulleys are in operation and the speed of one is known:

Multiply the speed of the shaft by diameter of its pulley and divide this product by diameter of pulley on the other shaft. The result is the speed of the second shaft.

Where a countershaft is used, to obtain size of main driving or driven pulley, or speed of main driving or driven shaft, it is necessary to calculate, as above, between the known end of the transmission and the countershaft, then repeat this calculation between the countershaft and the unknown end.

A set of gears of the same pitch transmits speeds in proportion to the number of teeth they contain. Count the number of teeth in the gear wheel and use this quantity instead of the diameter of pulley, mentioned above, to obtain number of teeth cut in unknown gear, or speed of second shaft.

Rule for Finding Size of Pulleys

$$d = \frac{D \times S}{S'} \qquad D = \frac{d \times S'}{S}$$

d = diameter of driven pulley.
D = diameter of driving pulley.
S = number of revolutions per minute of driving pulley.
S' = number of revolutios per minute of driven pulley.

SHAFTING, BELTING, PULLEYS AND GEARS

Shafting

The rule for determining the size of shaft for transmitting a given power at a given speed (8-foot centers for hangers) is as follows:

$$\sqrt[3]{\frac{\text{H. P. x 80}}{\text{R. P. M.}}} = \text{diameter in inches.}$$

When "H. P." = the horse power to be transmitted, "R. P. M."—the revolutions per minute.

Belts

The following formula is used to determine the length of belting:

$$\frac{(D + d \times 3.16)}{2} \times 2D^1 = \text{length}$$

When D = diameter of large pulley, d = diameter of small pulley, and D^1—distance between centers of shafting.

WEIGHTS AND SPEEDS OF FLYWHEELS

To obtain the weight of rim flywheels in pounds, find the volume of the rim in cubic feet and multiply by 450, the weight of a cubic foot of iron. To allow for the arms, weight must be added as follows:

For wheels up to 8 ft. diameter add 30% of rim weight.

For wheels from 8 ft. to 12 ft. add 40% of rim weight.

For wheels above 12 ft. add 30% of rim weight.

The limiting peripheral speeds for flywheels are as follows:

Cast iron	5000 to 6000 ft. per minute.
Cast Steel	10,000 ft. per minute.
Riveted boiler plate	20,000 to 25,000 ft. per min.

DISCOUNT TABLE

Given discount reduced to its decimal equivalent and also the remainder after substracting the decimal equivalent from unity 1.

Regardless of the rotation of discounts the net results are the same. Example: 50-10-20% is the same as 10-20-50%.

Discount	Decimal Equivalent	1.–Decimal Equivalent or the Multiplier	Discount	Decimal Equivalent	1.–Decimal Equivalent or the Multiplier	Discount	Decimal Equivalent	1.–Decimal Equivalent or the Multiplier
2½	.025	.975	15-10	.235	.765	30-12½	.388	.612
5-2½	.074	.926	15-10-5	.273	.727	30-16⅔	.4167	.5833
5-5	.098	.902	15-10-10-5-5	.379	.621	30-16⅔-5	.446	.554
10-2½	.123	.877	16⅔	.1666	.8333	30-16⅔-10	.475	.525
10-5	.145	.855	16⅔-5	.209	.791	30-16⅔-10-5	.502	.498
10-5-2½	.167	.833	16⅔-5-2½	.229	.771	32½	.325	.675
10-10	.19	.81	16⅔-5-5	.248	.752	32½-10	.393	.607
10-10-2½	.211	.789	16⅔-10-2½	.269	.731	32½-10-16⅔	.494	.506
10-10-5	.231	.769	16⅔-10-5-2½	.306	.694	33⅓	.3333	.6667
10-10-5½	.2345	.7655	16⅔-10-5-5	.323	.677	33⅓-5	.367	.633
10-10-7	.247	.753	20-5	.24	.76	33⅓-10	.401	.599
10-10-10	.271	.729	20-10	.28	.72	33⅓-10-5	.43	.57
10-10-10-5	.308	.692	20-10-5	.316	.684	35-5	.383	.617
10-10-10-5-2½	.325	.675	25	.25	.75	40-5	.43	.57
10-10-7-15	.359	.641	25-5	.288	.712	40-6	.436	.564
10-10-10-10	.344	.656	25-10	.325	.675	40-10	.46	.54
10-10-10-10-5	.377	.623	25-10-5	.359	.641	40-10-5	.487	.513
10-10-10-10-10	.41	.59	30-5	.335	.665	40-10-6	.493	.507
12½	.125	.875	30-10	.37	.63	40-10-7½	.501	.499
12½-2½	.147	.853	30-10-5	.402	.598	40-10-7½-5	.525	.475
12½-5	.169	.831	30-10-5-5	.432	.568	40-10-10	.514	.486
12½-10	.213	.787	30-10-5-5-5	.46	.54	40-10-10-5	.538	.462
15-2½	.172	.828	30-10-12½	.449	.551	40-10-10-10	.563	.437
15-5	.193	.807	30-10-12½-5	.477	.523			

DISCOUNT TABLE—Continued

Discount	Decimal Equivalent	1.–Decimal Equivalent or the Multiplier	Discount	Decimal Equivalent	1.–Decimal Equivalent or the Multiplier	Discount	Decimal Equivalent	1.–Decimal Equivalent or the Multiplier
40-10-10-10-5	.584	.416	50-10-10-5	.615	.385	50-16⅔	.583	.417
40-10-12½	.528	.472	50-10-10-5-5	.634	.366	50-16⅔-5	.604	.396
40-10-16⅔	.55	.45	50-10-10-5-5-5	.653	.347	50-20-5	.62	.38
40-10-16⅔-5	.573	.427	50-10-10-7	.624	.376	50-20-10	.64	.36
40-12½	.475	.525	50-10-10-7-15	.68	.32	50-25	.625	.375
40-10-16⅔	.55	.45	50-10-10-10	.635	.365	52½	.525	.475
40-15	.49	.51	50-10-10-10-5	.653	.347	52½-10	.573	.427
40-15-5	.515	.485	50—4-10's	.672	.328	52½-10-16⅔	.644	.356
40-16⅔	.50	.50	50—4-10's—5	.689	.311	55-5	.573	.427
40-16⅔-5	.525	.475	50—5-10's	.705	.295	55-10	.595	.405
42½	.425	.575	50—5-10's—5	.72	.28	55-10-10	.636	.364
42½-10	.483	.517	50—6-10's—	.735	.265	60-5	.62	.38
42½-10-16⅔	.569	.431	50—6-10's—5	.748	.252	60-5-5	.639	.361
45-5	.478	.522	50—6-10's-5-5	.76	.24	60-5-10	.658	.342
45-10	.505	.495	50—7-10's	.759	.241	60-10	.64	.36
45-10-5	.529	.471	50—7-10's—5	.772	.228	60-10-5	.658	.342
45-10-10	.555	.445	50—7-10's-5-5	.783	.217	60-10-5-5	.675	.325
45-10-10-5	.577	.423	50—8-16's	.784	.216	60-10-10	.676	.324
45-10-10-10	.599	.401	50-10-12½	.606	.394	60-10-10-5	.692	.308
45-10-10-10-5	.619	.381	50-10-15-5-5	.657	.343	60-10-15-5	.71	.29
45-10-12½	.567	.433	50-10-16⅔	.625	.375	60-15-5	.677	.323
45-10-16⅔	.588	.412	50-10-16⅔-5	.644	.356	60-20-5	.696	.304
45-12½	.519	.481	50-10-25	.663	.337	60-20-15	.728	.272
45-15	.533	.467	50-10-25-5	.68	.32	62½	.625	.375
45-15-5	.556	.444	50-10-25-10	.696	.304	62½-5	.644	.356
45-16⅔	.542	.458	50-12½	.563	.437	62½-7	.651	.349
50-5	.525	.475	50-15	.575	.425	62½-10	.663	.337
50-10	.55	.45	50-15-5	.596	.404	62½-10-5	.679	.321
50-10-5	.572	.428	50-15-10	.618	.382	62½-10-7	.687	.313
50-10-5-5	.594	.406	50-15-10-5	.637	.363	65-5	.668	.332
50-10-10	.595	.405	50-15-10-5-5	.655	.345	65-10	.685	.315

DISCOUNT TABLE

Continued

Discount	Decimal Equivalent	1.–Decimal Equivalent or the Multiplier	Discount	Decimal Equivalent	1.–Decimal Equivalent or the Multiplier	Discount	Decimal Equivalent	1.–Decimal Equivalent or the Multiplier
66⅔	.6667	.3333	70-10-10-10	.781	.219	80-10-10	.838	.162
66⅔-5	.684	.316	70-10-10-10-5	.792	.208	80-10-10-5	.846	.154
66⅔-10	.701	.299	70—4-10's	.803	.197	85-5	.857	.143
66⅔-10-5	.716	.284	70—4-10's—5	.812	.188	85-5-10-5-5	.883	.117
67½	.675	.325	70—5-10's	.822	.178	85-10	.865	.135
67½-10	.708	.292	70—5-10's—5	.831	.169	87½	.875	.125
70-5	.715	.285	70—6-10's	.84	.16	87½-5	.882	.118
70-10	.73	.27	70—6-10's—5	.848	.152	87½-5-10	.894	.106
70-10-5	.744	.256	80-5	.81	.19	87½-5-10-5	.899	.101
70-10-10	.757	.243	80-10	.82	.18	87½-5-10-5-5	.904	.096
70-10-10-5	.769	.231	80-10-5	.829	.171			

THE IMPORTANCE OF LOADING

To protect the durability and lasting finish on Youngstown Buckeye Conduit and to insure its arrival at destination in perfect condition, every possible precaution is taken in loading and bracing.

Inside View of Car Showing Careful Loading and Bracing

Only cars in first class condition, clean and leak-proof are used. Every bundle and length of conduit is carefully handled, in such a manner as to give the greatest protection. Many methods of bracing have been tried, but we find the method we now employ has proven superior.

MANUFACTURE OF YOUNGSTOWN BUCKEYE CONDUIT

Believing that only a few of those, who use Rigid Steel Conduit, have ever seen it made, we feel that a brief description of the processes used in the manufacture of Youngstown Buckeye Conduit will be of interest.

PIG IRON

The first step in the manufacture of Electrical Conduit is in the mining and selection of iron ore to be used in the manufacture of pipe. The ores used by The Youngstown Sheet and Tube Company come direct from its own mines in the Lake Superior region, the large variety produced by these mines making possible the careful selection and combination necessary to produce Pig Iron of the highest grade for the production of pipe. The second step is the smelting of these ores into iron, usually known as Pig Iron or blast furnace iron. This operation demands care and skill, especially in the preparation of ores and fuel. The coke used in a blast furnace has a marked effect on the iron it produces. The Youngstown Sheet and Tube Company has an important advantage in this respect as it not only mines its own ores and coal, but also makes its own coke, and is therefore in a position to provide the steel plants with both fuel and ore of the highest grade.

The company owns fifteen modern blast furnaces, having a theoretical annual capacity of 3,200,000 tons.

Most of these furnaces are directly connected with Open Hearth and Bessemer Steel Plants and are provided with by-product coke plants, in which their fuel is manufactureed. Each plant is equipped with a laboratory and every facility for the production of the highest grade of Pig Iron. Eight of these furnaces are located in the Youngstown district and seven in the Chicago district.

After the iron from a number of furnaces has been thoroughly mixed in order to secure uniformity, it is taken to the Bessemer Steel Plant. The molten metal is transferred to a converter, and a blast of air blowing through this molten metal generates intense heat, which burns out the impurities. After the heat is blown, it is cast into ingots and reheated in what are called Soaking Pit Furnaces, and then rolled into blooms or slabs. These blooms are then rolled into billets, and these billets again rolled into skelp, which is the name given to plates used in making pipe. All pipe for conduit up to and including 3" in diameter is made by the Butt-Weld process. Sizes larger than 3" are made by the Lap-Weld process.

BUTT-WELD PROCESS OF MAKING PIPE

In making Butt-Weld Pipe, the edges of the skelp are welded together at the time the tube is formed by passing the skelp through a die or "bell," which curves the hot skelp and welds the edges firmly by bringing them together under high pressure.

LAP-WELD PROCESS FOR MAKING PIPE

In the Lap-Weld process the skelp is first heated in what is called a bending furnace, and as it leaves the furnace, passes through a scarfing machine, where the edges are "scarfed" or beveled, so that when they overlap and are welded one on the other, the pipe will be approximately the same thickness at the weld as at any other point. The skelp then passes through a die or through power bending rolls, and is thus formed into a rough, unwelded tube. This unwelded tube is then conveyed to the welding furnace and heated to a welding temperature. It then passes through grooved rolls and over a ball or mandrel held firmly in place on a long bar. By means of the pressure of these rolls, the overlapping edges are firmly welded together.

The pipe then passes through "Size" rolls, then through "Cross Rolls," which straighten it and make it perfectly round.

All Butt-Weld and Lap-Weld Pipe is then carefully inspected to see that the welds are perfect.

The Butt-Weld material is then forwarded to the cutting department and passes through double hot saws that cut the pipe to the exact length. Lap-Weld Pipe is cut in machines to the exact length.

The Pipe is now ready for the Conduit Department and is then sent to the Cleaning or Pickling House.

PICKLING AND CLEANING

All pipe for Conduit is delivered from the Tube Mills as plain end and is pickled or cleaned in a Sulphuric Acid bath. Very careful attention must be given this process as clean pipe is absolutely essential to insure a high quality finished Conduit. As all pipe for Buckeye Conduit is pickled before threading, there is no danger of damaged threads. After the pipe leaves the pickle, it is washed and treated to neutralize the acid remaining on the surface.

It then passes to the inspection table, where each piece is given a careful inspection, both inside and out. The inspection of Conduit in this stage is very essential, and only highly trained inspectors are permitted to do this work. All pipe, which passes this inspection, is sent to the threading machines for threading and reaming.

BLACK ENAMELED CONDUIT

The threads are now inspected carefully, and if the pipe is to be black enameled, a protector is put on one end to keep the enamel out of the threads. The other end carries a coupling, and a nipple on the interior of the coupling is used while enameling to protect the coupling threads. The pipe is then loaded into cages and taken to the dipping department for the enameling.

After dipping, the conduit is allowed to set to insure uniform coating and prevent wrinkling. The loaded cages are then sent to the baking department and placed in the baking ovens where an even temperature is maintained by pyrometers. The enamel is baked to a high lustrous finish, having a thorough tight coat with sufficient elasticity to guard against cracking in any bending or forming operation, to which the conduit may be subjected during installation.

INSPECTION

The finished enameled conduit now goes to the inspection table, where it is very carefully inspected, both inside and out, and Underwriters' labels are applied. Material is then bundled and sent to the warehouse.

ELECTRO GALVANIZED CONDUIT

For the manufacture of Galvanized Conduit, the pipe after being threaded, reamed and inspected is transferred to the electro galvanizing department where it is again thoroughly cleaned before passing to the galvanizing units. This equipment is so arranged that the pipe is uniformly coated with zinc from one end to the other, and tests are continually made to insure proper weight of coating. A coat of baking enamel is now put on the interior, and it is then sent to the baking ovens for finishing.

YOUNGSTOWN COATED CONDUIT

This conduit is made the same as our regular galvanized conduit, but in addition to the regular finish, it is loaded into cages and dipped in a specially prepared mixture, which thoroughly covers both outside and inside. It is then baked under a certain temperature, which makes a very thorough coating, elastic and durable. The threads are then thoroughly brushed to remove any excess coating, which might remain on the threads. This extra coating, both inside and outside, means additional protection.

HOT DIP GALVANIZED CONDUIT

The specially selected pipe for this conduit is first thoroughly cleaned by pickling and then immersed in a bath of molten pure zinc. The pipe is then removed from this bath by a special process which leaves a clean, smooth coating of zinc on both the outside and inside of the pipe. The pipe is now accurately threaded. A coating of tough transparent enamel is baked on both the outside and inside of the conduit, leaving a smooth raceway through which the necessary wires may be readily fished.

ELECTRIC METALLIC TUBING

Descriptions of Electric Metallic Tubing processes on page 15.

INDEX

A

A. C. Generators and Motors 74, 75, 76, 77, 78, 79
Aluminum
  Conductivity of 129
  Electrical Conductors 129
  Stranded Wires 131
  Telephone Wires 130
  Weights of 129
Avoirdupois Weights 65

B

Belting 145
Black Enameled Conduit 9, 10, 11, 151
Bracing and Loading of Conduit 149
Bus Bar Data 136, 137
Bushings 138, 139, 140, 141

C

Carrying Capacities of Insulated Wires
  and Cables 54, 55, 56, 57, 58, 59, 60, 61
Climax Resistance Wire—properties 134
Comparative Resistances 132
Conductivity of Metals and Alloys 135, 143
Conduit Installations .... 45, 46, 47, 48 ,49, 50
Conduit Sizes for Wire and Cables ....
  .... 31, 32, 33, 34, 35, 36, 37, 38, 39, 40
Conduit Weights 13
Convertible System 39
Copper Bus Bar Data 136, 137
Couplings 13
Cubic Measures 65
Current Required to Fuse Wires 142

D

D. C. Generators and Motors 72, 73, 76, 77, 78, 79
Decimal Equivalents 64
Dimensions and Weights of Elbows 14
Diameter of circular Mil Cables
  Rubber Covered 110, 111
  Lead Encased 112, 113
Discount Tables 146, 147, 148
Dry Measures 66
Duplex Wire System 40

INDEX—Continued

E

Electrical Units 51
Elbows, conduit 13, 14
E.M.T.—Electrical Metallic Tubing 15
Enameled Conduit 13
Equivalent of wires 127
Equivalent values in different units 69, 70, 71

F

Fly wheels—weights and speeds 145
Formulas for determining—Amperes 128
  —H. P. 128
  —Kilowatts 128
  —Kilovolt Amperes 128
Four Wire System 37
Full Load currents of Motors 91, 92, 93, 94, 95

G

Galvanized Conduit 13, 152
Galvanized Conduit—Hot Dipped 13, 152
Gears 144, 145
Generators, A. C. 74, 75, 76, 77, 78, 79
Generators D. C. 72, 73, 76, 77, 78, 79

H

Hot Dipped Galvanized Conduit 13, 152

L

Lead incased wires 117, 118, 119
Linear Measures 65
Liquid Measures 67
List Price—Conduit 13
  Couplings 13
  Elbows 13
Loading and Bracing of Conduit 150
Lock Nuts 138, 139, 140, 141

M

Magnet Wire 126
Manufacture of Youngstown Buckeye Conduit 150
Measures—Avoirdupois 65
  —Cubic 65
  —Dry 66
  —Electrical Units 67
  —Linear 65
  —Liquid 67
  —Mariners 65
  —Troy 65

INDEX—Continued

Melting Point of Metals and Alloys 135
Mil 52
Minimum Size Wire for Motor Service 80
Motors A. C. 74, 75, 76, 77, 78, 79
Motors D. C. 72, 73, 76, 77, 78, 79
Motor Tables 80, 81, 102, 103, 104
Motor Duty ratings 126
Multiples 68, 69, 70, 71

O

Ohms Law 52

P

Properties of Climax Resistance Wire 134
Pulleys 144, 145

R

Resistances—Comparative 132
Rigid Conduit Industry Standard Specifications
  Enameled 16, 17, 18, 19, 20, 21
  Galvanized 22, 23, 24, 25, 26, 27, 28, 29
Rubber Covered Wires 114, 115, 116

S

Sales Conditions 8
Shafting 144, 145
Sheet Metal Gauges 63
Single Wire System 34
Spacing of Conduit Bushings & Lock Nuts 138, 139, 140, 141
Specifications, Rigid Conduit Industry Standard
  Enameled 16, 17, 18, 19, 20, 21
  Galvanized 22, 23, 24, 25, 26, 27, 28, 29
Square Measures 65
Standard Wiring Symbols 42, 43, 44
Stranded Aluminum Wires 131
Stranded Copper Conductors 120, 121
Symbols—Wiring 42, 43, 44

T

Tables of Multiple 69
Tensile Strength of Copper Wire 132
Three conductor convertible system 31
Three Wire System 36
Transformer Capacity for Motors 109
Transformer Connections 106, 107, 108, 109
Troy Weights 66
Two Wire System 35

INDEX—Continued

U

Units—Electrical 51
Units of Measure 51

V

Volts lost per 1000 feet per Ampere 62

W

Weights of Aluminum 129
Weight of Conduit 13
Weight of Couplings 13
Weight of Elbows 13, 14
Weights of Electrical Metallic Tubing 15
Weights and Measures 65, 66, 67
Wire Capacity of Conduit 30, 31
Wire Data
  Standard Stranded Copper Conductors 120, 121
  Weatherproof Copper Wires; Solid Conductors 122, 124
  Weatherproof Copper Wires; Stranded Conductors 123
  Fine Magnet Wire 126
Wire and Sheet Metal Gauges 63
Wiring Data for A. C. Motors 88, 89, 90
Wiring Formulae 52, 53, 84, 85, 86, 87
Wiring Symbols 42, 43, 44
Wiring Tables 82, 83

PRINTED IN U. S. A.
BY
THE YOUNGSTOWN SHEET AND TUBE CO.
Fifth Edition
1936

INTERNATIONAL

Digitized by

The Association for Preservation Technology International

For the

Building Technology Heritage Library

http://archive.org/details/buildingtechnologyheritagelibrary